LING

INSTRUCTIONS

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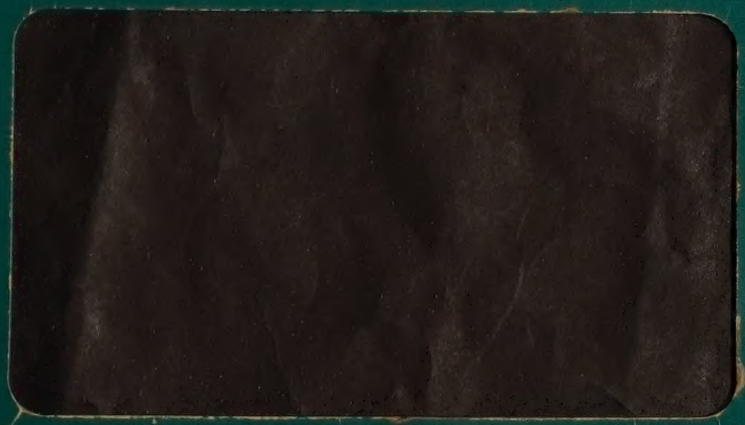
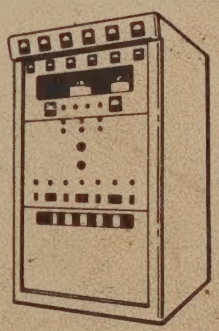


MP MASTER
MA34230

ELECTRONICS DIVISION

LING-ALTEC ELECTRONICS, INC.

MODEL PP-20/24 ELECTRONIC POWER SUPPLY



LING ELECTRONICS Division
LING-ALTEC ELECTRONICS, INC
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SAFETY NOTICE

This apparatus has been designed so as to afford all personnel maximum protection from electrical shocks and burns. The cubicle is fitted with control circuit interlocks of high-voltage AC and DC shorting switches which are actuated by the rear access doors. The interlocks open the power supply contactors while the shorting switch shorts the positive and negative terminals of the rectifiers. Thus, double protection against contact with high-voltage circuits is afforded operating and maintenance personnel. Moreover, a second interlock operates a contactor which disconnects the primary voltage from all exposed terminals.

While every practical safety precaution has been incorporated in this equipment, the following rules should be strictly observed:

1. KEEP AWAY FROM LIVE CIRCUITS. Under NO Circumstances should any person be permitted to reach within or in any manner gain access to the cabinet with the interlocked door closed (or with power supply line switches to the equipment closed); or to approach or handle any portion of the equipment which is supplied with power; or to connect any apparatus external to the enclosure to circuits within the equipment; or to apply voltages to the equipment for testing purposes while any non-interlocked portion of the shielding or enclosure is removed or opened.

2. DO NOT SERVICE OR ADJUST ALONE. Under NO Circumstances should any person reach within or enter the enclosure for the purpose of servicing or adjusting the equipment without the immediate presence or assistance of another person capable of rendering aid.

3. DO NOT TAMPER WITH INTERLOCKS. Under NO Circumstances should any access gate, door, or safety interlock switch be removed, short-circuited, or tampered with.

4. FIRST AID. Study first aid procedures in handling electrical shock.

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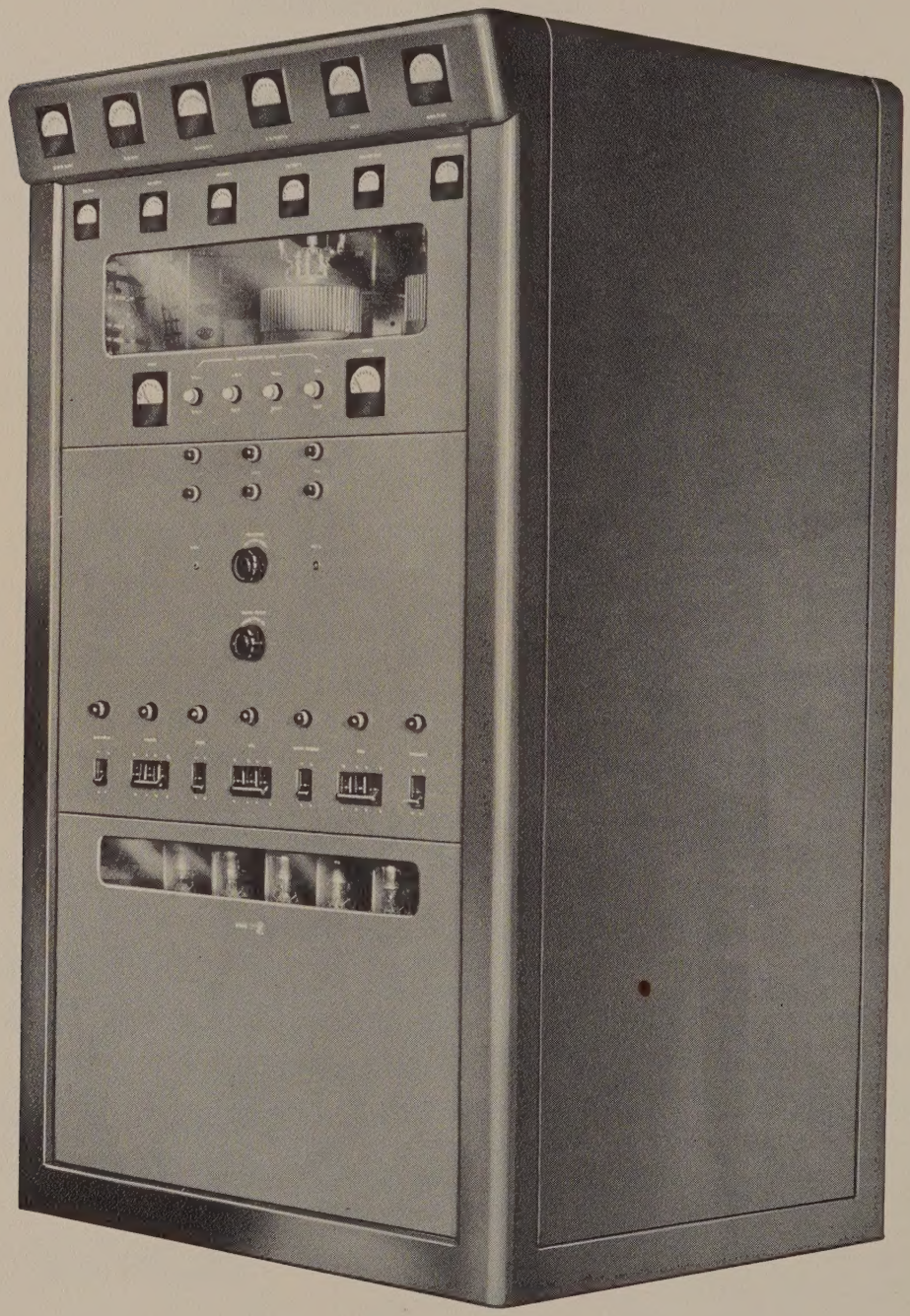


Figure 1-1. Model PP-20/24 Amplifier, Front View

SECTION 1
DESCRIPTION AND CHARACTERISTICS

1-1 GENERAL

The Ling Electronics, Model PP-20/24 amplifier (photograph) is an electronic power supply capable of supplying a 20-kva power output and is designed for vibration-testing applications in the 20-10,000-cps frequency range. Equipment normally associated with the Model PP-20/24 includes a signal source or master control console, and a vibration exciter (shaker). The Model PP-20/24 amplifier may be operated remotely by means of the master control console, or independently as a separate equipment item. The Model PP-20/24 amplifier is normally used with shakers of a 5000 force-pounds rating. This operation and maintenance manual contains data relative to the Model PP-20/24 amplifier only, and is considered as a separate operating equipment item.

1-2 PURPOSE

Purpose of the Model PP-20/24 amplifier is to amplify random-wave signals or sine-wave signals in a variable audio frequency and amplitude range, up to the full rated capacity of associated shaker equipment.

1-3 CHARACTERISTICS & SPECIFICATIONS

All components of the Model PP-20/24 amplifier are contained in one metal cabinet 90 inches high and 54 inches square at the base. All necessary operating controls for the amplifier are accessible on the front panels of the cabinet; the amplifier may be operated without a control console if desired. The cabinet contains the following components:

Model 112A preamplifier
Model 607 preamplifier power supply
Driver
Model 210A driver power and bias supply
Power amplifier
Power-amplifier power supply
Armature-protector circuits
Output transformer
A matching autotransformer
Field & degaussing power supply
Blowers
Relays, interlocks, operating controls,
Circuit breakers
Meters

Specifications for the Model PP-20/24 are as follows:

Power requirements	58-kva, 460 volt ± 5 % three-phase, 60-cps
Plate dissipation	24 kw continuous
Power output	20-kva into any load power factor between 1.0 and 0.22 leading or lagging, 20-3000-cps or 20-kw into resistive load, 20-10,000-cps
Distortion	Less than 3 % total, from 30-5000-cps
	Less than 5 % total, from 20-10,000-cps
Frequency response	Flat within ± 1-db, from 20-10,000-cps
Duty cycle	Continuous duty at full output

Hum and noise	At least 70-db below rated full output. 60-cps intermodulation eliminated by use of d-c on power-amplifier filaments.
Output voltage	Any one of the following rms voltages that are available by pushbutton selection: 370, 420, 460 or 500 volts.
Input signal voltage	1.0 volt rms from 600-ohm source, for full power output
Input impedance	10,000-ohms
Cooling	Forced air, 1700-cfm, 45°F rise (max)
Field supply	As required by shaker
Weight	5000 pounds total

1-4 TUBE COMPLEMENT

CIRCUIT	REFERENCE	TYPE	FUNCTION
Preamplifier	1V1	6SN7GTB	Amplifier/phase inverter
	1V2	6SL7GT	Amplifier
	1V3	PL6569	Amplifier,
	1V4	PL6569	Amplifier, intermediate
Driver	3V7	3X3000F1	Cathode follower
	3V8	3X3000F1	Cathode follower
Power amplifier	3V9	ML-5531	Class AB_2 amplifier
	3V10	ML-5531	Class AB_2 amplifier
Armature protector	11V1	6279	Power-supply dump thyratron
	11V2	6279	Power-supply dump thyratron
	11V3	VR-105/0C3	Voltage regulator, bias
Preamplifier power supply	6V1	966	Rectifier, 6-kv
	6V2	966	Rectifier, 6-kv
	6V3	966	Rectifier, 6-kv
	6V4	966	Rectifier, 6-kv
	6V5	5R4GY	Rectifier, 550-v
Power-amplifier power supply	3V1	673	Rectifier, 9-kv
	3V2	673	Rectifier, 9-kv
	3V3	673	Rectifier, 9-kv
	3V4	673	Rectifier, 9-kv
	3V5	673	Rectifier, 9-kv
	3V6	673	Rectifier, 9-kv

SECTION 2
OPERATION

2-1 PREPARATION

Initial installation of all Ling electronic power supplies is accomplished under the direction of expert field service personnel supplied by Ling as a part of the equipment contract. The customer normally provides only the primary power, floor space, interconnecting conduit to shaker, and physical assistance by fork lifts, etc. to unload the amplifier and set it in place. Ling personnel perform the necessary interconnections, such unpacking operations as may be necessary (removal of tie-downs, insertion of components shipped separately, etc.) initial checkout and test, and any briefing type instruction for customer personnel. Therefore, this operation and maintenance manual does not include special data on installation of equipment.

Before operating the Model PP-20/24 amplifier, make the following checks:

a. Make sure the proper primary power is available.

b. Check the cabinet doors to see that they are closed.

c. Make sure the proper shaker is connected to the amplifier, and that there are no specimens mounted on it that would be damaged by normal excitation of the shaker.

2-2 OPERATION

All operating controls, switches, circuit breakers, indicators and meters necessary for operating Model PP-20/24 amplifier are located on the front panels of the amplifier cabinet. The amplifier can be operated without an accessory master control console provided that the necessary jumpers and connections have been made to control circuits at the time of installation. If a master control console is used, the amplifier may still be operated independently from the console, or remotely at the console as desired (once the main circuit breakers have been closed). The following steps should be taken in placing the Model PP-20/24 amplifier into operation:

a. Turn on all circuit breakers on the front panel of the amplifier cabinet.

b. Press the green FILAMENT combination pushbutton/indicator (31S1). The green lamp should go out, and the red lamp should light. This operation closes relay 3K2. The P.A. blowers should now come on, along with the shaker blowers, field supply, console power, rectifier and driver blowers, preamplifier filaments, armature-protector filaments, and low-voltage supply. If air flow is correct on the P.A. tubes, relay 3K4 should operate, initiating the step-start timing cycle (10-15 seconds) and energizing the P.A., driver and P.A. rectifier filaments at reduced voltage.

c. Adjust shaker field and degauss current to proper value for the shaker, in use, by varying controls for transformer 3T19 and resistor 3R15, while observing meters 3M3 and 3M4, respectively

d. Select proper output voltage for the shaker in use, and press correct pushbutton to select that voltage.

e. After completion of step-start timing cycle, the P.A., driver and P.A. rectifier filaments should come on at full voltage, and the main time-delay cycle (5 minutes) will be initiated. When warmup time is complete the green lamp at the DRIVER pushbutton will light, indicating that the driver may be turned on.

f. Turn on the driver by pressing the DRIVER pushbutton/indicator (31S1). The green lamp should go out, and the red lamp below it should light.

g. Observe the following meters for correct indication as noted:

PRE-AMP	3M5	6 KV
DRIVER PLATE	3M6	2 KV
P.A. BIAS 1	3M11	Approx 300 V
P.A. BIAS 2	3M12	Approx 300 V
P.A. FIL 1	3M9	6.3 V
P.A. FIL 2	3M10	6.3 V

i. If the driver voltages are sufficient shaker blower on, driver on, and no overloads, then the POWER AMPLIFIER pushbutton/indicator green lamp should light when the master gain control at console (if used) is turned to the OFF position. Press the P.A. pushbutton (31S5). The green lamp should go out, and the red lamp just below it should light. Observe the following meters for correct indication as noted:

P.A. PLATE	3M14	9KV
P.A. PLATE 1	3M7	0.7a
P.A. PLATE 2	3M8	0.7a

NOTE

P.A. plate current at console meter should read 1.4a.

j. The signal may now be increased at the master control console or other signal source, as called for by operating specifications. At full signal, P.A. plate current should increase to beween 3.0 and 4.0 amperes total, or 1.5-2.0 amperes per tube, depending on frequency. (For 20 kw output into resistive load, sine-wave. Slightly higher currents will be noted at higher frequencies; this is normal). Note readings of OUTPUT (voltage) meter 3M2, and OUTPUT(current) meter meter 3M1. They should correspond with the correct values for the characteristic curves of the shaker(s) in use, and are dependent on frequency.

2-3 ADJUSTMENTS

Adjustments available on the front panels of Model PP-20/24 amplifier are, in addition to the field and degaussing controls already mentioned,BIAS 1 and BIAS 2 voltage adjustments 3R30 and 3R33. These are screwdriver-type adjustments located on either side of the FIELD CURRENT control, and should not require frequent resetting. They should be set so that the quiescent plate current on each amplifier tube (indicated by meters 3M7 and 3M8) is the same .7 amp at no signal. The grid bias indicated by meters 3M11 and 3M12, will be approximately - 300 volts.

2-4 RUNNING TIME INDICATOR

RUNNING-TIME indicator 3M13 is mounted on the front panel. This meter indicates cumulative running time on the amplifier filaments. Notation should be made of running-time meter readings, and date, in the equipment log at periodic intervals. This information is necessary should a tube warranty claim be filed, and also useful in determining when tubes should be replaced in the event a busy operating schedule precludes replacement only after a failure. Normally, the expected life of a tube is several times the minimum warranty period.

SECTION 3
THEORY OF OPERATION

3-1 INTRODUCTION

The Ling Model PP-20/24 is basically a conventional audio amplifier, designed to cover the frequency range of 5-5000-cps, for application in vibration-testing work. The amplifier block diagram is shown in Figure 3-1. An input signal of 1.0 volt rms supplies the 112A preamplifier, which consists of a two-stage 6SN7 input amplifier/phase inverter, 6SL7 balanced amplifier, and a PL6569 push-pull intermediate amplifier developing a large driving voltage. The preamplifier output supplies a push-pull cathode follower, 3X3000F1 tubes, which transforms the preamplifier output impedance and supplies the driving power required by the Class AB_2 power amplifier, which uses push-pull ML-5531 tubes.

Two feedback loops are used: one from the driver to the preamplifier, and the other around the entire amplifier. Dump circuits are provided in the power amplifier and power-amplifier power supply, to discharge stored energy during shutdown and protect the shaker armature. There are four main d-c power supplies: the 607 preamplifier supply providing voltage for the input stages and intermediate amplifier; the 210A power supply providing plate and bias voltages for the driver; the 9 kv power supply for the power amplifier; and the filament supply for the power-amplifier tubes.

The component chassis of Model PP-20/24 are standardized in the complete Ling line of high-power amplifiers, for economy reasons and to simplify customer maintenance in those installations consisting of a number of different Ling units. For example, the 112A preamplifier, 607 power supply, 210 power supply driver and most of the armature-protector circuits are essentially the same in all Ling amplifiers. Since the preamplifier must be capable of supplying the full driving voltage required by the larger tubes of the line (the ML-5682's used in the Model PP-175/240 amplifier), it is evident that there is considerable reserve capacity in the Model PP-20/24. For the same reason the 3X3000F1 driver tubes are running very lightly loaded in comparison to their ratings.

3-2 PREAMPLIFIER

Fig. 3-2 is a simplified schematic of the entire Ling Model PP-20/24 amplifier. The preamplifier input stage 1V1 is transformer. coupled to the input signal coming from the from the master control console or from some other external signal source. The shielding method employed insures against ground loop problems, and permits running a circuit balanced to ground if desired. Feedback voltage from the amplifier output is developed across the input cathode resistor. The second half of 1V1 is a phase inverter that supplies one-half of the balanced amplifier 1V2. The other half of 1V2 is supplied from the output of 1V1. The coupling circuit and plate circuit of 1V1 contains frequency and phase compensation capacitors to equalize response and maintain high-frequency balance in push-pull stages.

The balanced amplifier, 1V2, provides the grid swing required by the intermediate amplifier tubes 1V3 and 1V4 and also allows low-frequency balancing to be accomplished by adjustments of the balancing potentiometer in the cathode circuit of 1V2. The coupling circuit between 1V2 and the intermediate amplifier contains a high-frequency boost circuit to equalize phase shift and frequency response in the over-all amplifier and provide the required margin for stability, since two feedback loops are involved. This boost circuit also compensates for the rather high input capacitance (due to Miller effect) of the PL6569 tubes 1V3 and 1V4. Feedback from the driver tubes, 3V7 and 3V8, is applied to the cathodes of balanced amplifier 1V2.

The Penta PL6569 tubes, 1V3 and 1V4, operate as Class A voltage amplifiers. It is their function to develop the full grid-voltage swing required by the power-amplifier tubes, since the cathode-follower stage contributes no gain. It is for this reason that a 6-kv power supply is used at this point. The full-signal output swing of 1V3 and 1V4 is about 600 volts peak, in the Model PP-20/24 amplifier, for each tube. Hum-balancing potentiometers are in the filament circuits of each PL6569 tube.

3-3 DRIVER

Tubes 3V7 and 3V8, Eimac Type 3X3000F1 triodes, operate as a push-pull cathode follower, to supply the grid driving power required by power-amplifier tubes 3V9 and 3V10. This stage has a voltage gain of about 0.9. This biasing arrangement shown in Fig. 3-2 involves a negative supply in the cathode return circuit, and this same supply is used to establish the grid-bias potential for the cathode-follower (and power amplifier) tubes. The grid-to-ground potential of 3V7 and 3V8 may be varied from approximately − 750 volts to − 500 volts by means of potentiometers 3R30 and 3R33. Over this range, the cathode (filament center tap) potential will vary from about − 350 to − 115 volts, and the plate current will vary from about 415 ma to 471 ma. The nominal operating points are 3X3000F1 grid-to-ground voltage, − 625 volts; plate current 425 ma per tube; cathode-to-ground voltage, − 300 volts. This produces a standing current of 0.7 ampere per tube in the power amplifier. With 425 volts rms grid swing, the cathode-follower produces a peak swing of 540 volts, so that each power-amplifier tube swings from − 840 to + 240 volts at full signal The cathode-follower output impedance is low enough to supply the driving power (1 ampere peak grid current per tube at + 240 volts peak grid voltage, or about 240 watts peak) required by the power amplifier, and introduce negligible distortion.

3-4 POWER AMPLIFIER

The power amplifier in the Model PP-20/24 amplifier is a pair of Machlett ML-5531 air cooled triodes, operating in Class AB_2. Class AB_2 is being used in Ling amplifiers in order to supply the peak voltages and currents required in random-wave testing. Class AB_2 amplifier tubes can operate with high peak efficiency over a large ratio of peak-to-average power, because the load impedance is not limited to something greater than the tube plate impedance. The peak-to-average crest factor requirement comes from the accepted stipulation in random-wave testing that the 'G' value at the shaker must be at least three times the rms value without amplifier overloading. Thus the peak current and peak voltage delivered must be three times their rms values. By careful design and the use of over-all feedback, distortion is kept very low, and is comparable with any Class AB_1 amplifier.

The power amplifier receives its signal from the cathode-follower stage and is coupled to the shaker by way of output transformer 3T17 and autotransformer 3T18. A 9-kv power supply feeds the power amplifier; this power supply is discussed in a later paragraph. A three-phase, full-wave silicon-rectifier-type d-c power supply is used to supply filament voltage to each of the ML-5531 tubes. Four 4-ufd capacitors bypass the filaments to ground, to provide a low-impedance radio-frequency path to ground, avoiding transient and parasitic problems.

The armature- and power-supply-dump circuits shown in block form in Fig. 3-2 are discussed in the next section.

3-5 DUMP CIRCUITS

The armature-dump and power-supply-dump circuits dissipate the energy stored in the shaker, output transformer, and power supply in the event of a hazardous overload or flashover, and thus prevent damage to the shaker and amplifier components. Fig. 3-3 is a simplified schematic of the dump

circuits. Two thyratron tubes, 11V4 and 11V5, Type 5563A, are connected across the primary of output transformer 3T17 in series with 150-ohm dissipating resistors. Whenever these tubes conduct, they connect the resistors across the transformer, dissipating the energy stored in the armature and output transformer. Thyratrons 11V1 and 11V2, Type 6279, are the power-supply dump tubes. Whenever these tubes conduct, they short the 9-kv power supply through the 10-ohm plate resistors of these tubes and the series resistor of 4-ohms, to ground. This discharge current also flows through overload relay 3K11 and thermal relay 3K24, so that if the primary power has not already been interrupted, it will be when tubes 11V1 and 11V2 fire.

The hold-off and trigger circuit (Fig. 3-3) for the dump thyratrons consists of thyratron 11V6,Type 5563A, and two negative bias supplies. Tube 11V6 is normally supplied with the full 9-kv plate voltage,with its grid returning to a bias voltage of about − 95 volts through the secondary of current transformer 11T6. This bias is normally sufficient to keep 11V6 from conducting, so that there is no voltage developed across the 200-ohm resistor in the filament return. Tubes 11V1 and 11V2, therefore, are normally at approximately zero bias, which for the 6279 is sufficient to keep the tube from conducting. However, if the bias is interrupted on tube 11V6, due to the shorting of a (normally-open) shaker overtravel switch (dotted connection in Fig. 3-3) or the opening of a (normally-closed) shaker overtravel switch, or if the bias is overcome by a positive spike of voltage appearing across the secondary of current transformer 11T6, then tube 11V6 will conduct and a positive voltage of about 1500 volts will appear instantaneously across the 200-ohm cathode resistor, and hence also on the grids of tubes 11V1 and 11V2. This positive voltage is sufficient to cause tubes 11V1 and 11V2 to fire, and discharge the power supply through a total of about 9-ohms resistance, and also causing overload relay 3K11 to trip (if it has not already done so) and turn off the primary power.

The instant tubes 11V1 and/or 11V2 fire, the center tap of the output transformer (3T17) is brought down to about 5-kv positive with respect to ground,decaying toward zero as the stored energy is dissipated. Capacitor 11C1 is still charged positively to the full 9-kv, however, and it must discharge through the grid-circuit resistors and bias supply associated with tubes 11V4 and 11V5. Thus a transient positive grid signal appears at tubes 11V4 and 11V5, causing these tubes to conduct and discharge the energy stored in the output transformer and shaker armature through the 150-ohm plate resistors of these tubes.

All thyratrons automatically extinguish after discharge, since the plate voltages decay toward zero; resetting is not necessary. The small capacitors provided at the grid of each thyratron are to filter low-energy spikes and any possible radio-frequency signals that might cause the thyratrons to fire erratically. An adjustable one-ohm resistor shunts the primary of current transformer 11T6, and sets the level at which the circuit will trigger. A ball gap is provided in the grid circuit of thyratrons 11V1 and 11V2 to protect the tubes and components against damaging transient voltages. Excessive transients may develop due to inter-electrode or stray capacitances in the circuit.

3-6 POWER AMPLIFIER SUPPLY

The main power-amplifier power supply (Fig. 3-4) is a conventional three-phase, full-wave rectifier, with heavy filtering to reduce hum and provide good regulation for the low-frequency signals that must be handled by the amplifier. The primary of of main power transformer 3T5 is supplied from a 460 volt three-phase source. The secondary of transformer 3T5 can be restrapped for delta instead of wye, to produce a d-c output voltage of about 5.2-kv for break-in of new tubes.

The filament step-start circuit shown in Figure 3-4 is arranged so as to hold the filament voltages of the 673 rectifier

tubes, the 3X3000F1 driver tubes and the ML-5531 power-amplifier tubes at approximately 1/2 the full filament voltage for a period of about 15 seconds governed by time delay relay 3K28. Pressing the filament button energizes relay 3K4 as described in a later section,and relay 3K5 automatically closes after the time cycle of 3K28 is complete, shorting out the limiting resistors. This step-start circuit is a necessity with most high-power tubes,to avoid an excessive in-rush of current to cold filaments, which can damage the tubes by overstressing the filament strands.

3-7 PREAMPLIFIER POWER SUPPLY

The preamplifier power supply (Fig. 3-5) provides the 6-kv required by the intermediate amplifier tubes 1V3 and 1V4 and the 550 volts required by the preamplifier input stages, 1V1 and 1V2. The 607 preamplifier power supply uses type 966 mercury vapor rectifier tubes 6V1 through 6V4 in a conventional full-wave bridge rectifier to supply 6-kv at the relatively low current requirements of the intermediate-amplifier tubes (about 140 ma). Relay 6K1 is an overcurrent relay, with operating range adjustable by potentiometer 6R10.Full-wave rectifier 6V5 supplies the + 550 volt output required by the preamplifier tubes 1V1 and 1V2. This supply is heavily filtered with an R-C filter, to give very low hum output.

3-8 DRIVER AND BIAS SUPPLIES

The 210A power supply is shown in Fig. 3-6. Each rectifier consists of a series stack of eight type 1N1695 rectifiers, to handle the peak-inverse voltage requirement. Each individual rectifier is shunted by a 0.01-mfd capacitor, to equalize the voltage across each unit of the stack.

The chassis contains a positive and a negative supply, each supplied from a separate secondary on an external three-phase transformer (3T3). Each supply has its own overload relay in the grounded side of the output circuit. 'Brute-force' filtering using 20-ufd of capacitance is used; negligible hum is produced because of the capacitor size and because of the three-phase full-wave connection and regulation is inherently good because of the low voltage drop across the 1N1695 rectifier stacks. Overload relays 2K1 and 2K2 are incorporated in the ground returns of the + 2-kv supply.

3-9 FIELD & DEGAUSSING POWER SUPPLY

The field-supply circuit is shown in a separate field supply section. The field supply used in any given Model PP-20/24 Amplifier depends on the shaker requirements. Metering of current is provided for, with field and degaussing current meters located at the amplifier. These meters are duplicated on the console (if used). The field supply shown in a separate field supply section is adjustable by means of variable transformers 3T19A through 3T19C, which are tapped across part of the primary of power transformer 3T4. The supply is a conventional three-phase full-wave rectifier using silicon rectifying elements and a single capacitor filter. Thermal relays 3K21 and 3K22 protect the field and degaussing circuits.

3-10 INTERLOCK CIRCUITS

All Ling amplifiers are provided with complete protection of all circuits and large components. A simplified schematic of the over-all interlock and impedance changing circuitry of the Model PP-20/24 amplifier is shown in Fig. 3-7. The interlock system is supplied with 120-vac power from a step-down transformer (3T1). Cubicle lighting and convenience outlets are pro - vided from this same transformer, opening the cubicle door, turn on the light and outlets (switch 3S9)opening the interlock chain so that none of the circuits can be operated.When circuit breaker 3S8 is turned on, relay 3K1 closes, and supplies power to the primary of transformer 3T1,energizing

the interlock system. Operating FILAMENT pushbutton (31S1) operates relay 3K2, interlocked with overload relay 6K1 on the 607 power supply chassis, which then supplies power to the rectifier and driver blowers, low voltage (550V) power supply and miscellaneous items, as well as the remainder of the interlock chain. Provided that the blowers are delivering proper air to the power amplifier tubes (circuit breaker 3S1 operates these blowers) the air interlocks will be closed, and relay 3K4 operates energizing time-delay relay 3K28 (not shown in Fig. 3-8) which in turn operates relay 3K5 after approximately 15 seconds. During this period of time, step-start resistors 3R62, 3R63 and 3R64 are in series with the filament circuit supplying the power amplifier, driver and power-amplifier power-supply filaments, to allow them to warm up under reduced voltage. Relay 3K5 shorts out these resistors and applies full voltage to these filaments, and also energizes time-delay relay 3K6 and running-time meter 3M13. After approximately 20 minutes relay 3K6 operates, permitting the driver to be turned on, interlocked with plus and minus overload relays and the cabinet doors.

Finally, when the driver is operated by closing the relay 3K7, the power amplifier may be operated if the various interlocks are closed leading to pilot relay 3K8. Note that the gain control at the console (if used) must be turned down in order for relay 3K8 to be operated initially, although once operated the gain control may be advanced In the event that the amplifier is operated without use of a console and the customer desires (at the risk of possibly damaging specimens and the shaker) to operate the amplifier from an external signal source not equipped with a gain interlock, terminals 26 and 27 must be shorted together on terminal board 3TB10.

The following conditions have to exist in order for the high voltage to be turned on:

Cubicle light and outlets off (door closed)
Filaments on
Blowers on and proper air to P.A.
Time delay complete (step-start and regular)
No 6-kv overload
No driver plus overload
No driver minus overload
No P.A. overload (instantaneous or thermal)
No excessive dissipation at P.A. (tube temperature OK)
No overload at shaker
Shaker blower on
Driver on
Driver plus voltage sufficient
Driver minus voltage sufficient
Gain control turned to "OFF"

If the above conditions all exist, then pilot relay 3K8 can be operated, which in turn operates relay 3K9, energizing the high-voltage power supply and placing 9-kv on the power amplifier plates.

3-11 IMPEDANCE CHANGING CIRCUITS

Impedance-changing circuits (Fig. 3-7) make it possible to properly match the amplifier to the shaker or shakers used with it. Relays 3K17 through 3K20 accomplish this by connecting the shaker to one (and only one) of the output taps on autotransformer 3T18 (see Fig. 3-2). The control circuit for these four relays is shown in the upper right portion of Fig. 3-7. If the power-amplifier high voltage is on, relay 3K8 is operated, so that power is removed from the impedance-changing circuit. Tap changing cannot be done under load. Latching type relays 3K13 through 3K16 are operated by the appropriate Output Impedance Selector pushbuttons located on the amplifier and duplicated on the console (if used). As may be seen from the simplified circuit, if the latching coil of any of these four relays is energized, the release coils of all remaining relays will be energized, so that only one relay may be operated at a time. If two pushbuttons are pressed at once, nothing happens. Also, the use of latching relays makes it unnecessary to reset taps after a complete shutdown of the amplifier.

Shown also in Fig. 3-7 is a silicon rectifier for relays 3K17 - 20, inclusive.

This rectifier is used only on amplifiers Serial No. and up, since a change to d-c relays has been made on these units. For detailed information on this rectifier and on connections, consult the complete diagrams included in Section 5 of this manual.

3-12 SAFETY FEATURES

In addition to the many interlocks provided for equipment protection, automatic grounding switches are installed in the cubicle for the purpose of discharging all high-voltage points appearing in the cubicle, whenever the doors are opened. The 6-kv, 9-kv, − 2-kv, and + 2-kv supplies (and B − connection) are all shorted to ground by this switch. The grounding switch is a type specially designed for Ling equipment and operates by a heavy, positive spring action upon opening of the cubicle doors. The contacts are discs, large and heavy enough to insure that the switch will not significantly deteriorate with continued use. As still another safety feature grounding hooks are provided just inside each cubicle door.

3-13 COOLING

All tubes in the Model PP-20/24 amplifier are air cooled. Blowers 3B3 and 3B4 are three-phase blowers for cooling the power amplifier tubes; blower 3B1 is a single phase blower for cooling the rectifier tubes; single-phase blowers 3B2 and 3B5 cool the driver tubes. The cooling system is designed with enough flow (1700-cfm) to use air at normal ambient temperatures (even in hot climates), and filters are used on air inlets. Allowable rise in air temperature is 45° F. From the standpoint of the amplifier special air conditioning and exhaust ducting is not required; however, personnel comfort might make exhaust ducting desirable if the amplifier is installed in a confined area.

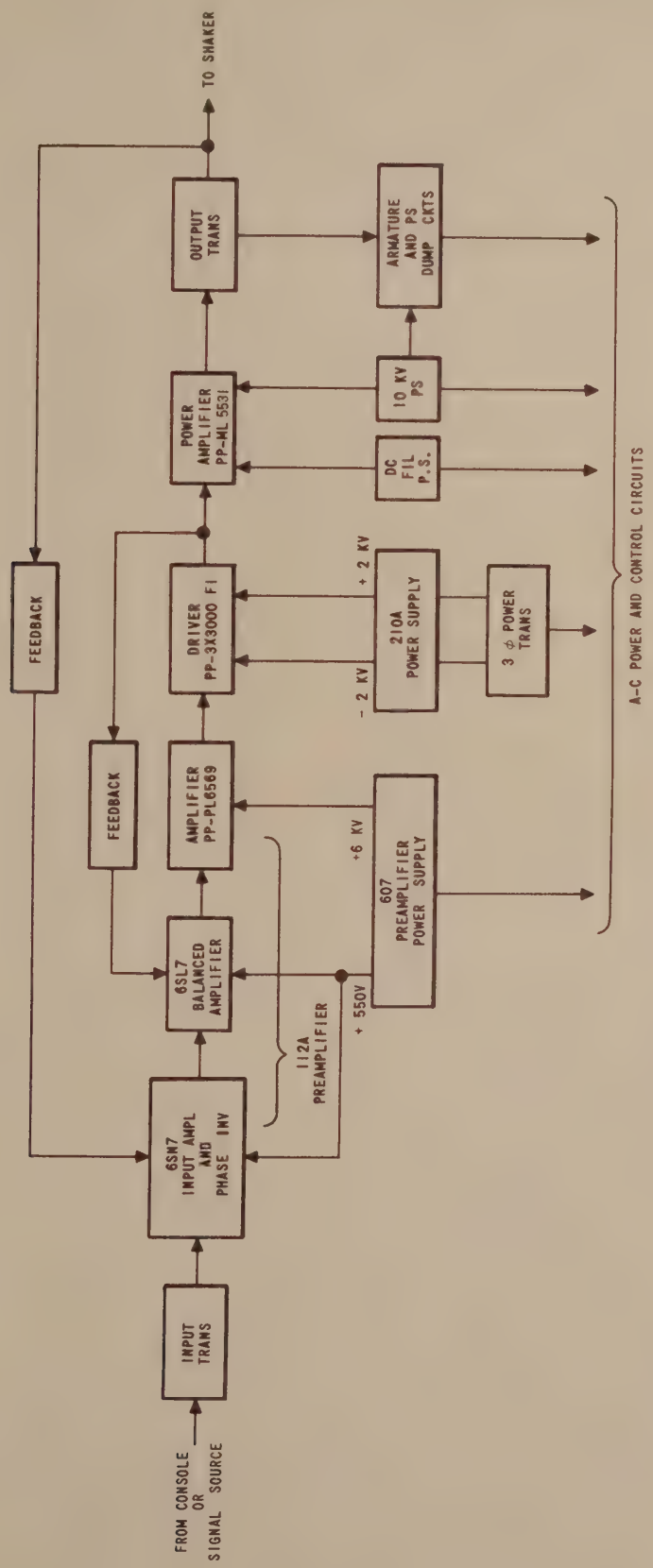
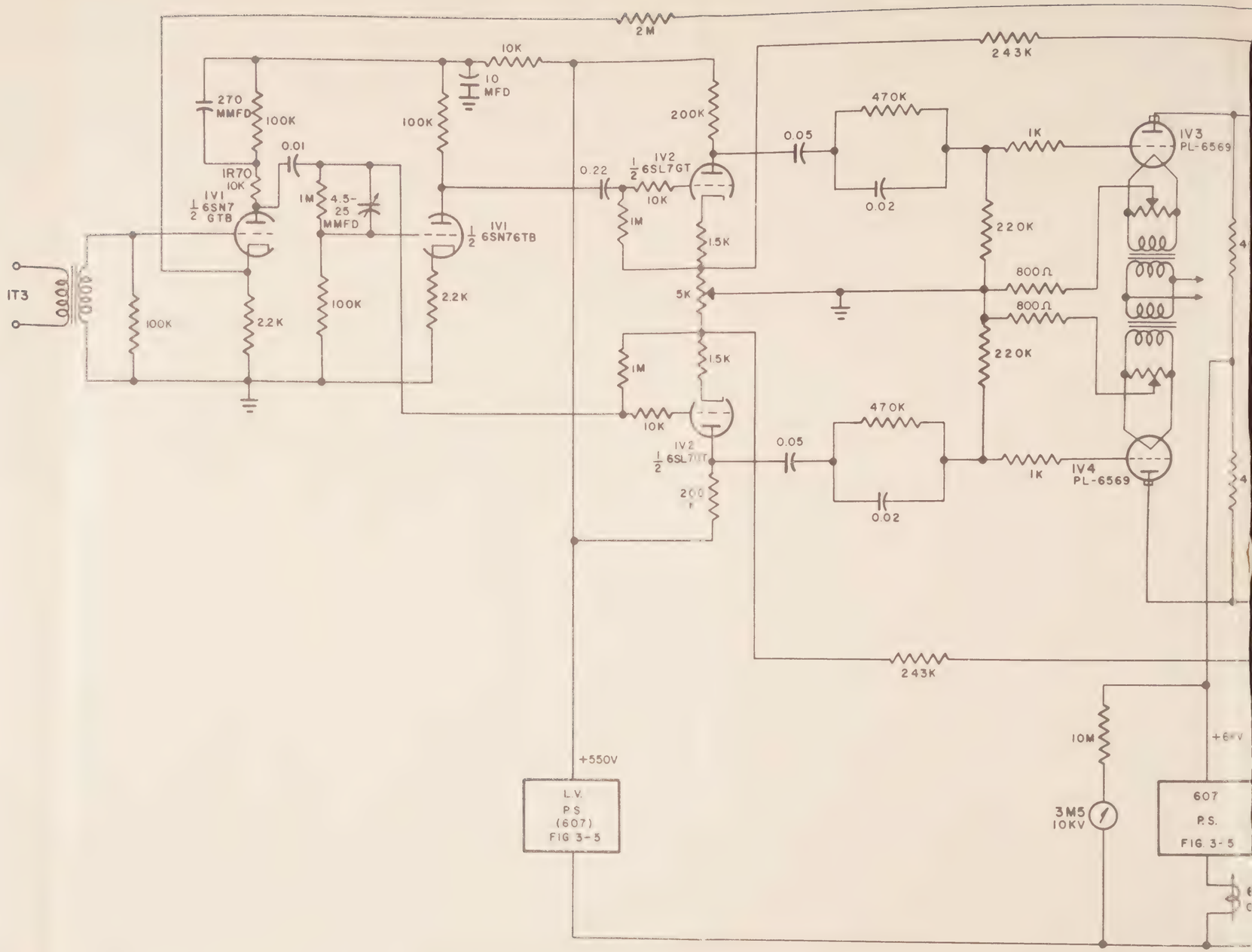


Figure 3-1. Model PP-20/24 Amplifier, Block Diagram.


2M
10K
243K
270 MMFD
100K
10 MFD
100K
200K
470K
0.05
1K
IV3 PL-6569
0.01
IR70 10K
0.22
IV2 ½ 6SL7GT
10K
0.02
IV1 ½ 6SN7 GTB
1M
4.5-25 MMFD
IV1 ½ 6SN76TB
1M
1.5K
220K
IT3
100K
2.2K
100K
2.2K
5K
800Ω
800Ω
1M
1.5K
220K
470K
10K
IV2 ½ 6SL7GT
0.05
1K
IV4 PL-6569
200
0.02
243K
10M
+550V
+6KV
L.V. P.S. (607) FIG 3-5
3M5 10KV
607 P.S. FIG. 3-5

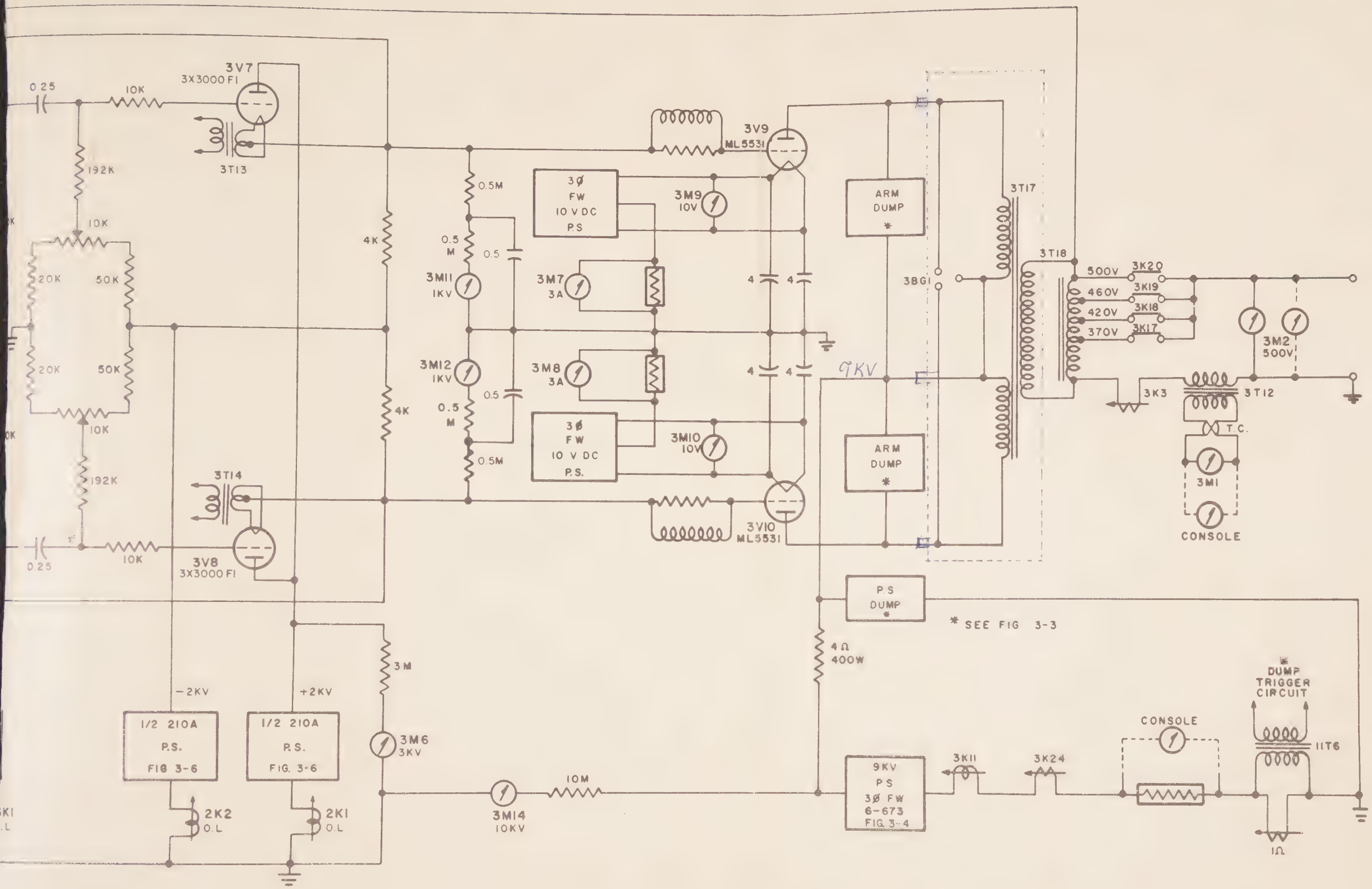


Figure 3-2. Amplifier, Simplified Schematic Diagram.

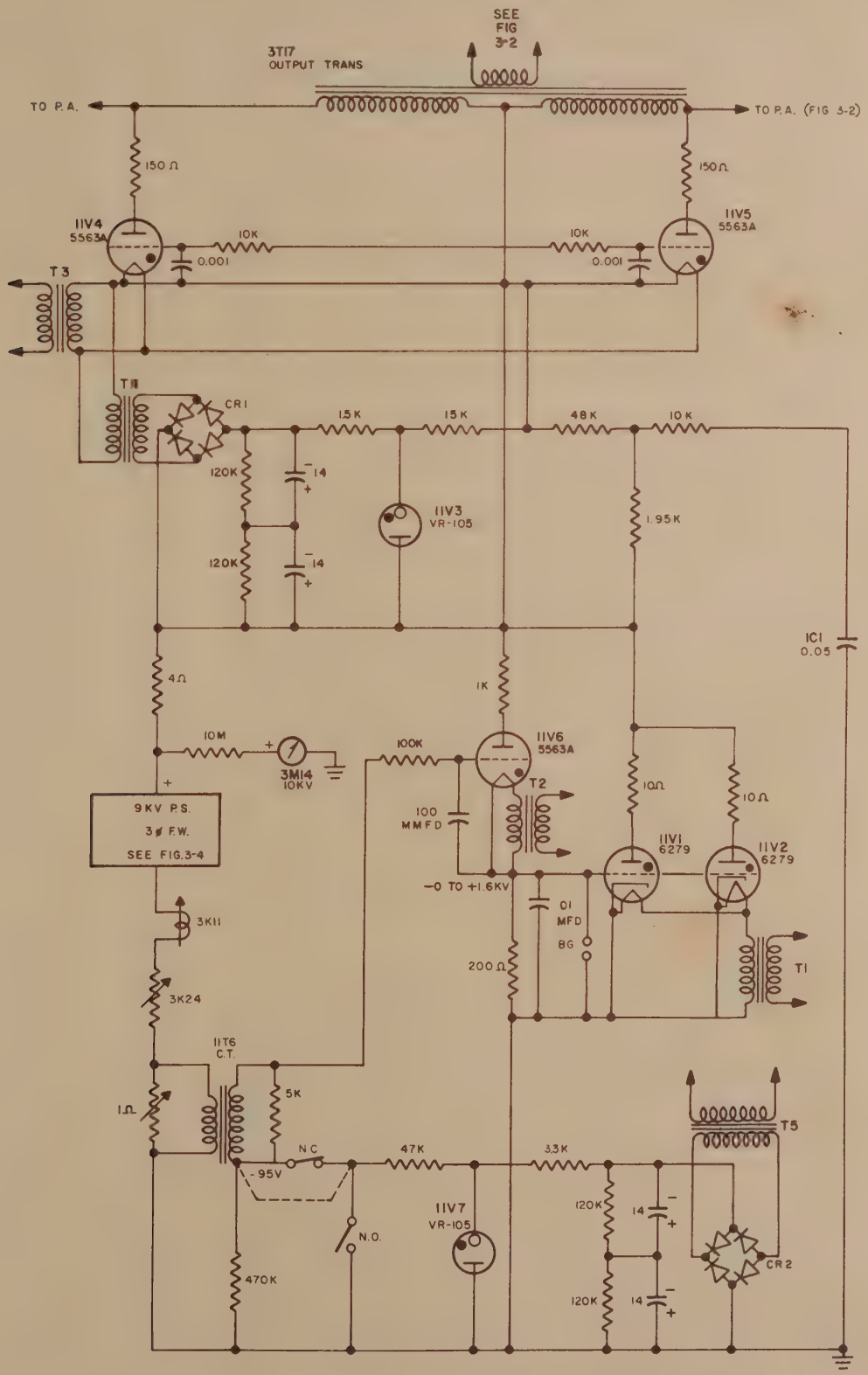


Figure 3-3. Armature Protector and Dump Circuit, Simplified Schematic Diagram.

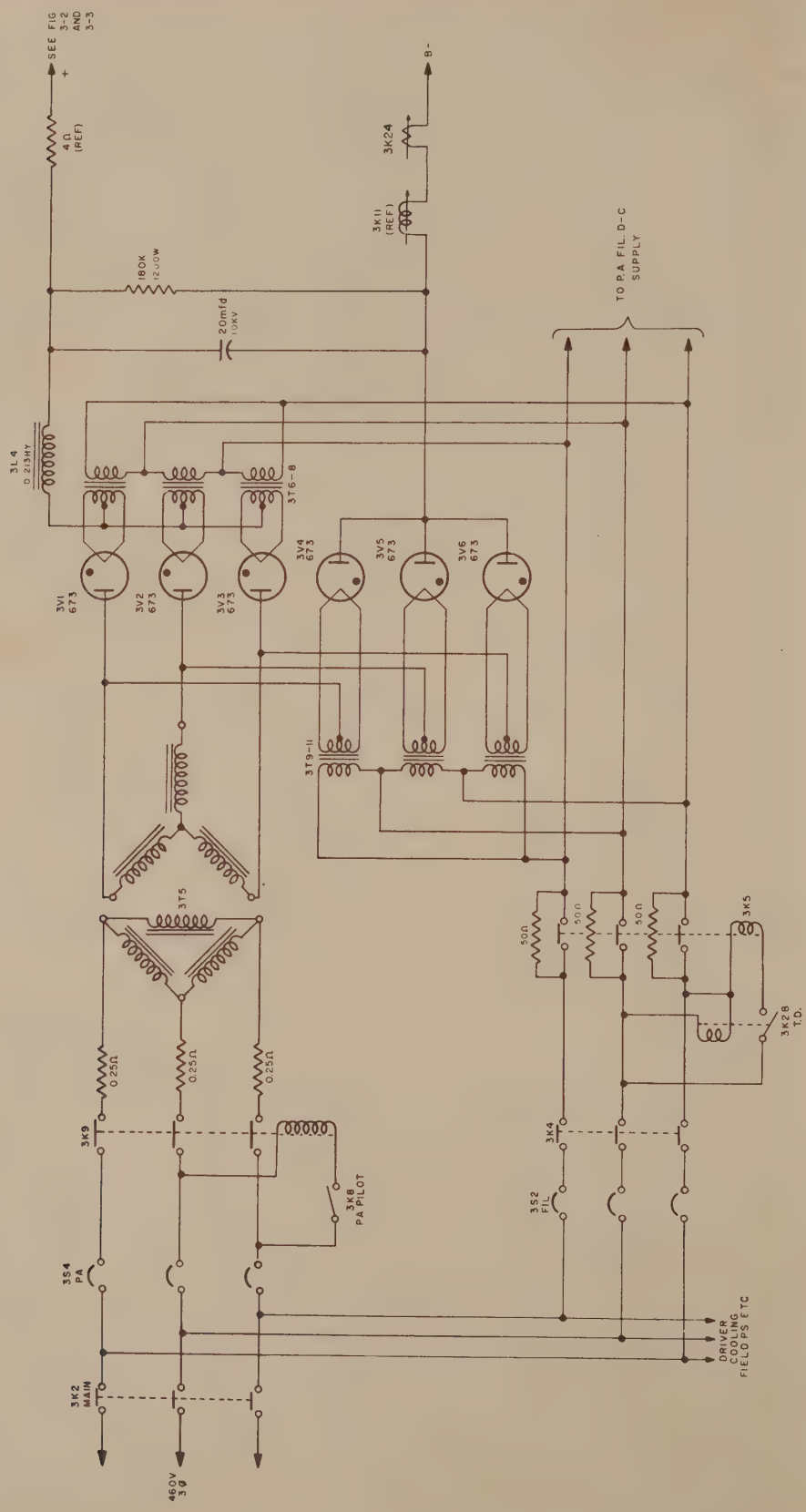


Figure 3-4. Power Amplifier High Voltage Power Supply, Simplified Schematic Diagram.

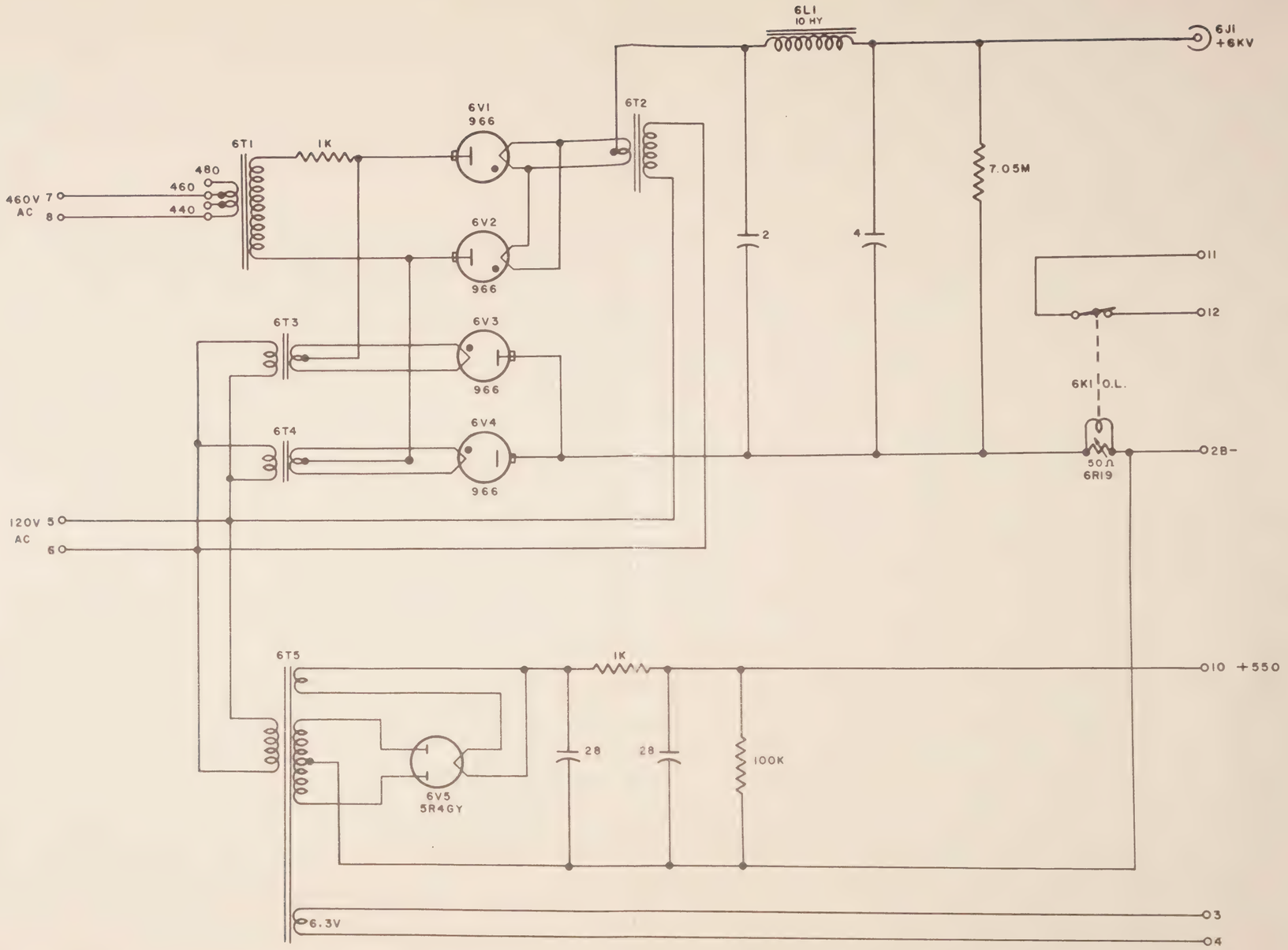


Figure 3-5. Pre-Amplifier Power Supply, Simplified Schematic Diagram.

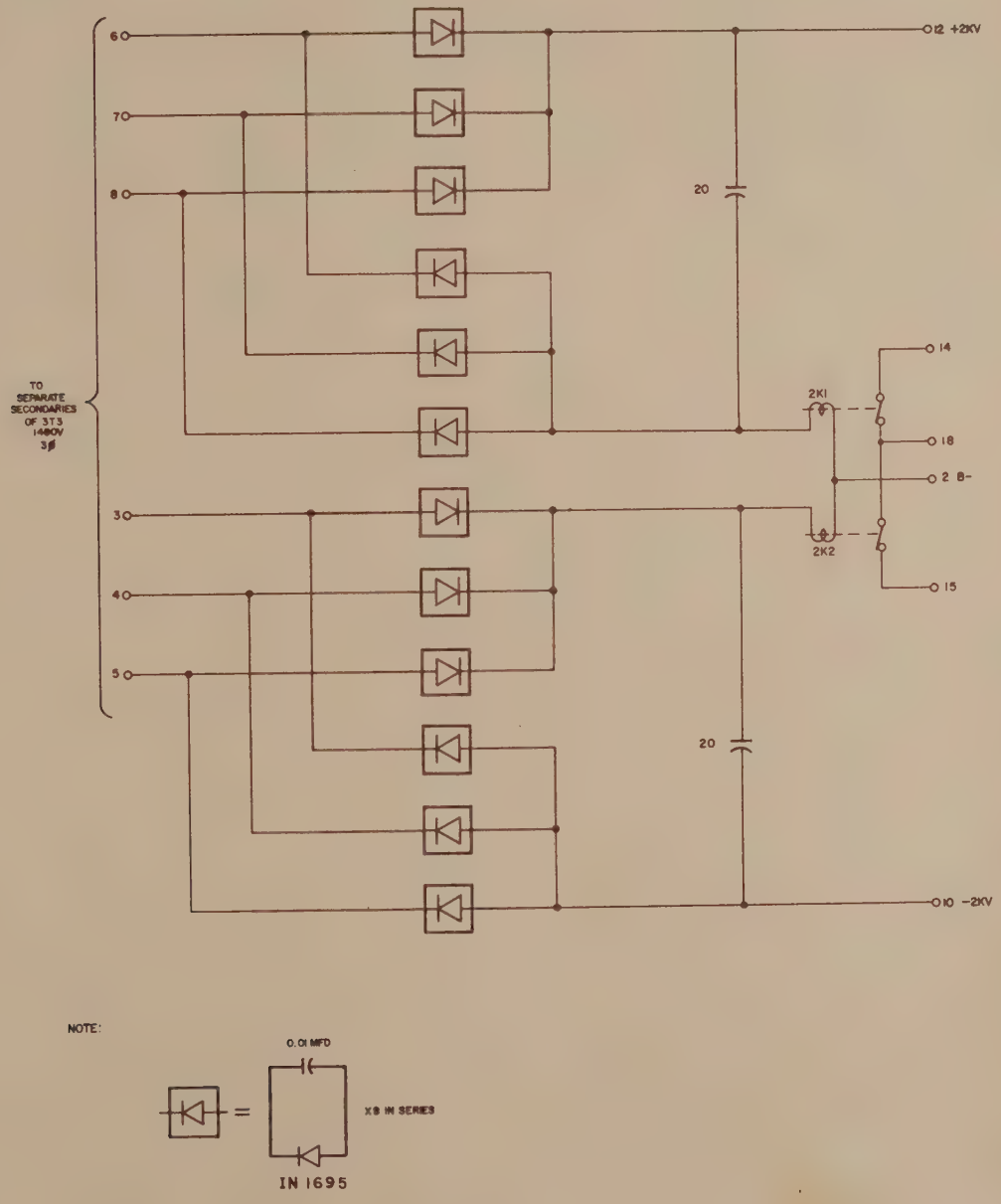


Figure 3-6. Simplified Schematic of 210A Power Supply, Model PP-20/24 Amplifier.

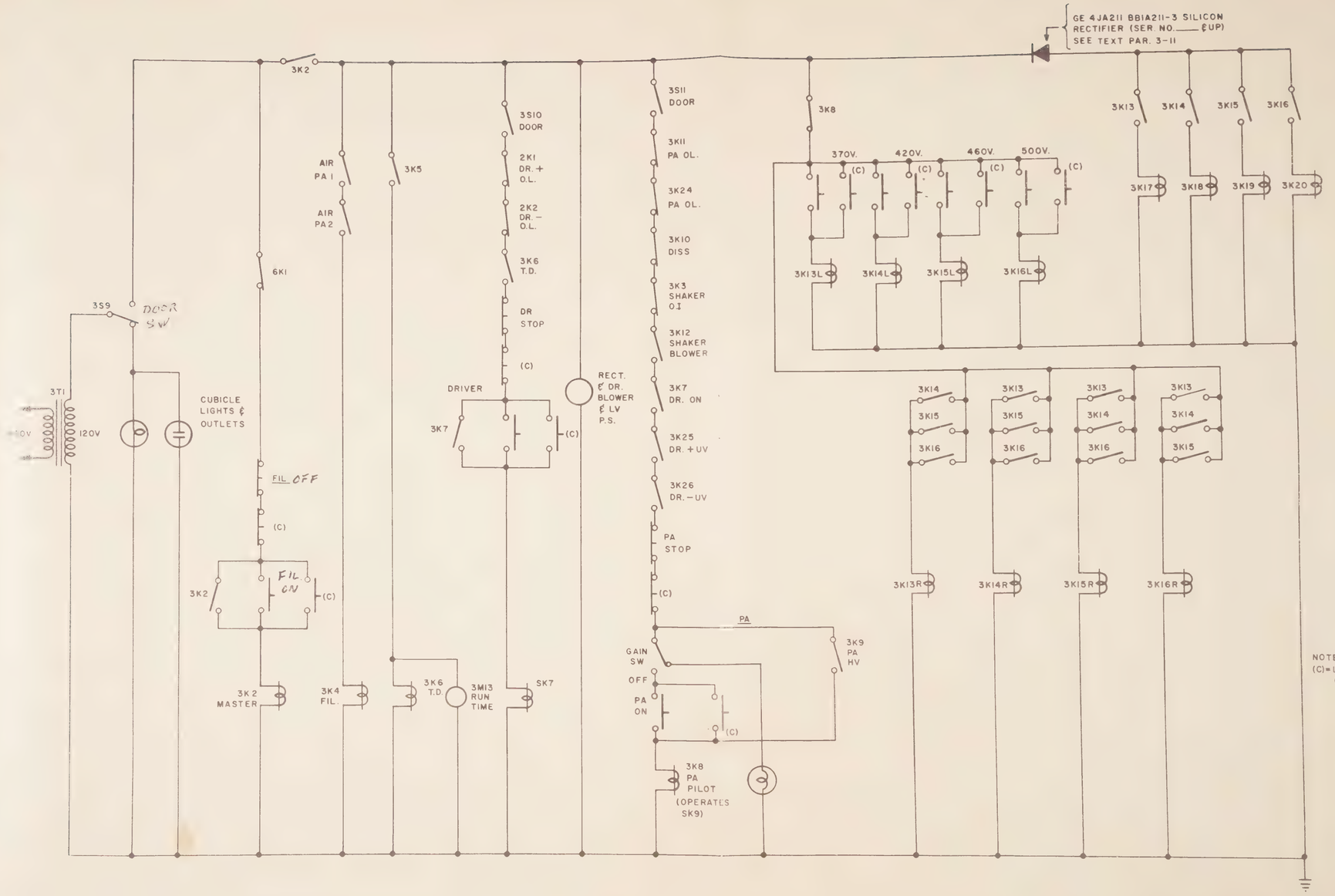


Figure 3-7. Interlock Circuits, Simplified Schematic Diagram.

SECTION 4
MAINTENANCE

WARNING

Lethal voltages exist in the Model PP-20/24 amplifier. Never attempt work inside the cabinet with the power on, and always use grounding rod to touch all high-voltage points before entering cabinet. If special tests or checks require the placement of meters, test equipment, etc., inside the cabinet to be viewed during amplifier operation, arrange these to be visible from outside of cabinet, temporarily removing the air filters on the rear doors if necessary. Do NOT attempt to jumper interlocks in order to work inside cabinet with power on.

4-1 ANALYSIS

Before attempting maintenance or repair of Model PP-20/24 amplifier, make certain that the amplifier is actually at fault. An improperly mounted specimen on the shaker may make it appear that the amplifier has a low power output. Rattles or loose connections in the shaker can cause severe distortions in the acceleration waveform. Troubles may exist in the control console, signal source, shaker, accelerometers or specimen. Carefully and methodically localize the trouble by making logical and orderly tests before assuming the amplifier to be at fault.

4-2 INTERLOCK PROBLEMS

Although the larger Ling amplifiers are equipped with a 'Supervisory Control Box' to aid in locating interlock difficulties, this is not a standard equipment item on the Model PP-20/24 because there are fewer interlocks involved.Frequent reference to the simplified interlock schematic,Fig. 3-8 will be found helpful in locating interlock difficulty.

Phase rotation should remain the same after initial installation and checkout, because three-phase blowers are used for the power amplifier tubes and it is important that these motors turn in the correct direction. Inadvertent change in phase rotation, as for example due to improper electrical changes in the plant power system, could cause the air switches to remain open, thereby preventing P.A. and P.A. rectifier filaments from coming on, and preventing operation of the driver and P.A. voltage supplies!

Sagging floors or other conditions causing the cabinet not to be level can cause difficulties with door interlocks and with proper door closing.

Insufficient driver plate and bias voltages (plus and minus 2-kv supplies) will prevent operation of the P.A. high voltage.

A frequent occurrence is forgetting to turn down the master gain control before trying to operate the P.A. high voltage. A special indicator lamp (C11 on console, not on amplifier) is provided to indicate this condition. The gain control must be turned down before the P.A. high voltage can be turned on, in those installations where a control console and this circuit is used.

4-3 TUBE REMOVAL

WARNING

Use grounding rod to touch all high-voltage components when entering cabinet and before attempting tube removal.

Only normal, well known precautions need be followed when removing tubes from the

Model PP-20/24 amplifier, except for the driver and power-amplifier tubes. To remove the 3X3000F1 driver tubes, proceed as follows:

a. Remove tube filament connections at transformer. Do not attempt to remove connections from top of tube, as they are an integral part of the tube.

b. Remove grid-ring connector.

c. Loosen clamps securing base of tube, and carefully pull tube from chassis, being very careful not to strike tube against nearby objects.

To remove the ML-5531 power-amplifier tubes, proceed as follows:

a. Remove the two filament connectors and the grid connector at tube.

b. Loosen the two knurled hold-down screws on the tube mounting flange.

c. Carefully lift tube out of socket using the handles attached to the tube.

4-4 TUBE INSTALLATION

Tube installation is the reverse of the removal procedure. In tightening the knurled hold-down screws on the ML-5531 tubes, do not tighten excessively, as this may bend cooling fins. The screws should be finger tight.

4-5 TUBE BREAK-IN

To increase ML-5531 life and prevent operating difficulties from shut-downs, a filament and plate break-in period is recommended for new tubes (break-in has already been accomplished at the factory on initial tubes; this procedure applies when changing tubes). The break-in procedure is as follows:

a. Enter the cabinet and re-strap the secondary of plate transformer 3T5 for delta instead of wye, by removing straps between H1-H3-H5 and strapping H1-H4, H2-H5, and H3-H6. The connections leading to rectifiers remain on H2, H4 and H6. This reconnection will produce a d-c output of 5.2-kv instead of 9-kv.

b. Turn on tube filaments, following the procedure given in Section 2.

c. After the ML-5531 filaments have been operating for approximately one-half hour, turn on the P.A. plate voltage (now 5.2-kv). Run for approximately one-half hour with no audio signal. During this time frequent dumping may occur as tubes clean up. Turn on voltage again after each dump interruption.

d. Increase audio signal (amplifier working into shaker or dummy load) until plate current to power amplifier is approximately 1 ampere per tube. Run in this condition for approximately one-half hour. Dumping will continue periodically as tubes clean up. Turn on voltage again after each dump interruption.

e. Enter cabinet (CAUTION: USE GROUNDING RODS) and re-strap transformer 3T5 for wye connection, by removing straps H1-H4, H2-H5 and H3-H6 and reconnect H1-H3-H5.

f. Again turn on plate voltage, and run with no signal until frequency of dumping decreases. Then gradually increase signal. When dumping frequency decreases, the amplifier is ready for operation.

When replacing tubes other than the ML-5531 power-amplifier tubes, the above procedure is not necessary, but extra filament warmup time (20-30 minutes) is recommended before plate voltage is applied, particularly for mercury-vapor rectifiers, thyratrons, driver and intermediate-amplifier tubes.

4-6 ADJUSTMENTS

The following adjustments are normally made at the factory, and seldom if ever need to be changed in the field, even after tube and/or component replacement; the adjustments should not be made unless absolutely necessary. Negligible improvement in performance will result from trying to better factory adjustment.

(1) POWER-AMPLIFIER BALANCE

An unbalanced condition indicated by unequal plate currents to the power-amplifier tubes is commonly the result of one tube or tube section aging faster than the other in one or more of the four push-pull stages of the amplifier. The most satisfactory solution in this case is replacement of the low tube or tubes in the amplifier; balance can be restored over a limited range by the preamplifier balance control, but not always without some distortion increase. To adjust the preamplifier balance control, arrange to have the amplifier operate at or near full load, with sine-wave signal in the mid-range of frequencies (50-1000 cps, 500-cps is a good choice if this is not near a shaker resonance point), and note the amount of unbalance. By means of the access holes provided at the rear of the cabinet adjust balance control 1R26 on the rear of the 112A pre-amplifier.

After the above balancing has been done check the balance at high frequencies, say 5000-cps. Unbalance at higher frequencies can occur due to changes in tube and stray capacitances in the phase-inverter section of the preamplifier. Adjustment should never be necessary unless some of the resistors or capacitors in the critical portion of the divider circuit associated with 1V1 are changed so that the divider is no longer compensated. Should high-frequency unbalance exist after low-frequency balance has been obtained, it will be necessary to remove the 112A preamplifier chassis, and perform the compensation on the bench. Perform the following:

a. Remove preamplifier chassis from cabinet.

b. Jumper terminals 1 and 2 on the preamplifier terminal strip.

c. Supply 6.3 volts, 1.2 amperes current capacity, to terminals 4 and 5.

d. Supply 500 to 550 volts-dc to terminal 10 (positive) and terminal 1 (negative).

e. Connect a low-distortion oscillator to terminal 3, ground on terminal 1.

f. Connect an oscilloscope to the grids of intermediate amplifier tubes 1V3 and 1V4, Type PL6569, with the X input on one grid and Y input on the other, ground to terminal 1 or chassis.

g. Set oscilloscope for equal gain on each amplifier, and switch the oscilloscope so as to use the X amplifier without sweep.

h. Set oscillator for approximately 0.1 volt rms, and a frequency of approxiately 10,000 cps.

i. Adjust trimmer capacitor 1C11 for minimum phase shift (best straight line on oscilloscope).

NOTE

All the above balancing procedure is based on the assumption that the bias voltages have been previously adjusted to be equal for each power-amplifier for each power-amplifier tube, or nearly so such that standing current (no signal) is equal for each tube.

(2) HUM AND NOISE ADJUSTMENT

If excessive hum and noice is suspected in the amplifier, verify by shorting input terminals 33 to 34 to 35 on the main input terminal strip 3TB10, or 1 to 2 to 3 on the 112A preamplifier terminal strip 1TB1, and

observing the output to the shaker at terminal strip 3TB30 (terminal 2 is ground) using an oscilloscope. Adjust filament center-tap potentiometers, 1R35 and 1R38, on the preamplifier chassis for minimum hum.This adjustment should seldom, if ever, be necessary even with changes in PL6569 tubes.

(3) BALL GAP ADJUSTMENT

Ball-gap spacing on the output transformer primary is fixed by the manufacturer at 0.5" and should not be changed.If tampered with, reset to 0.5". The ball gap (11BG1) in the grid circuit of power-supply dump tubes 11V1 and 11V2 must be set using a 'high-potter' or high-voltage, low-current source, should setting ever be required. To set 11BG1, remove the lead from the high (ungrounded) side of the gap, and connect high-potter to the gap and to ground. Adjust spacing for flashover at 2.5-kv, tighten, remove high-potter and reconnect.

(4) DUMP SENSITIVITY

Dump sensitivity should not need adjusting unless the control has been inadvertently or intentionally turned. Proper setting for resistor 11R36 on the shelf bracket below armature-protector chassis is 15 degrees from the full stop counterclockwise position.

(5) 6-kv OVERLOAD RELAY

Should it ever be necessary to adjust the 6-kv over-load relay, the 607 power-supply chassis should be removed from the cabinet, and a variable 0-6 volt d-c source (300-ma current capacity) connected across the coil of relay 6K1. Adjust relay potentiometer, 6R19, so that relay actuates at 200-ma current.

(6) DISSIPATION RELAY AND METER

Dissipation relay 3K10 and the associated dissipation meter on the console are supplied by series-connected thermocouples attached above the power amplifier tubes. Resistor 3R13 (50-ohms, 4 watts) is in series with the thermocouples, and controls the sensitivity. Adjustment should be necessary only if the control has been tampered with or if new thermocouples are installed. To adjust this control, it will be necessary to lower the bias on the power amplifier tubes until the power input with no signal is 24-kw total (plate current 1.333 amperes per tube at 9-kv plate voltage), and allow the temperature to stabilize at this input for approximately 15 minutes. Adjust 3R13 until the DISSIPATION meter on the console reads 5 millivolts. The dissipation relay 3R13 should operate at this setting.

(7) OTHER ADJUSTMENTS

There are no other adjustments that need to be made on the Model PP-20/24 amplifier. High-voltage overload relay 3K11, a PJC type, is set at the factory for approximately 6 amperes and should not be changed.The other overload relays for field, degaussing, shaker, driver overcurrent, driver undervoltage are all fixed and cannot be changed except by changing components. Air switches 3S26 and 3S27 do not need to be adjusted. The taps on 607 power-supply transformer 6T1 do not need to be changed even if line voltage does not correspond to the factory setting,as the intermediate-amplifier plate voltage is not critical in Model PP-20/24 because of the reserve capacity available.

4-7 TROUBLESHOOTING

TROUBLE	LOCATION	REMEDY AND/OR CAUSE
Excessive noise in acceleration waveform (sine-wave)	External	Check mounting of specimen and check shaker for rattles and loose connections.

		Check signal source at control console.
	Internal	Check low-voltage power supply.
		Check driver power supply.
Excessive hum	External	Check signal source at control console.
		Check for possible open ground in input cable from console.
		Check for open ground or other defect in accelerometer wiring.
	Internal	Check hum-balance adjustments 1R35 and 1R38.
		Check all power supplies.
		Check for defective 3X3000F1 tubes.
		Check for heater-cathode shorts in input 6SN7 and 6SL7 tubes, preamplifier.
Excessive Distortion	External	Check mounting of specimen and check shaker for rattles and loose connections.
		Check signal source at control console.
		Check for overloading in equalizers, filters, and servo in console.
NOTE Resonance of the shaker or specimen (or both) may magnify normal distortion many times.		Check Shaker for bad bearings or blower malfunction.
	Internal	Check P.A. bias voltages.
		Check P.A. plate current balance with and without signal.
		Check to see that proper impedance tap is in use.
		Check preamplifier tubes by substituting new ones.
		Check driver and P.A. tubes. Meter indications will generally show up malfunctions.
Repeated dumping	External	Short circuit in shaker armature, or overtravel.

		Excessively high transients in input signal from console.
	Internal	Shorts in P.A. tubes, or gassy tubes.
		Shorts in P.A. output transformer.
		Armature protector too sensitive (shunt 11R36 tampered with).
		Open grid capacitors on armature-protector thyratrons.
		Shorts in high-voltage supply.
		Interlocks opening up. Check doors, overload relays, under-voltage relays, dissipation relay, etc.
		Grid filament shorts in driver or P.A. tubes.
		Output transformer ball gap set too close.
		Tools lying inside cabinet too close to high-voltage points.
		Debris in cabinet causing shorts.
Amplifier does not respond to turn-on procedure in all respects	External	Check 460-volt external power.
		Check to see that master gain control is turned down (located on console).
	Internal	Check to see that all circuit breakers are on.
		Check all interlocks, especially cabinet doors that may not be fully closed. One or more over-load relays could be stuck. Air switches might not be closed, possibly due to blower malfunction or incorrect phase rotation.

4-8 HUM, NOISE & DISTORTION TESTING

The following procedure may be followed to determine if excessive hum, noise or distortion observed on accelerometer waveforms is externally caused, or if it is due to defects in the amplifier.

a. Disconnect signal input lead from amplifier at 3TB10 terminals 33, 34 and 35 and short these three terminals together on the terminal strip using a short length of bare wire. Operate the amplifier, with shaker connected normally If hum, noise, or distortion

disappears, the amplifier and shaker are not at fault, and the trouble is in the signal source at console (including filters, equalizers, etc.) or possibly in the console-to-amplifier wiring, and open ground, for example. If the hum, noise or distortion persists, then the trouble is in the amplifier or shaker, or in associated instrumentation. In this event, proceed to the next step.

b. Check connections and installations of accelerometers and wiring from shaker to console instruments. Ground loops or imperfect grounding frequently cause excessive noise and hum to appear. Observe voltage waveform at amplifier output terminals and note whether noise, hum or distortion also appears there. In some cases it will be beneficial to disconnect the shaker and substitute a dummy load. A water load is easiest to construct, using a suitable container and two metal plates approximately 24 in. x 24 in spaced approximately 6 to 8 in. apart. (This load will suffice for short periods only, as the water will boil away). If it is determined by these tests that the trouble is not in the shaker or associated instrumentation, then it is the amplifier. Proceed to the next step.

c. Hum, noise or distortion in the amplifier may be caused by malfunction of the low-voltage power supply, excessive ripple in any of the power supplies, heater-cathode shorts on the input tubes, or by a variety of other causes. Ripple on the 550-volt supply should not exceed 5 volts rms. It should not exceed 10 volts rms on the 6-kv supply.

CAUTION

When connecting oscilloscope to 6-kv supply, use a good isolating capacitor such as 0.01 or 0.02-mfd 7.5-kv in series with oscilloscope 'hot' lead, with the capacitor placed at the power supply or point of connection to 6-kv. Oscilloscopes will not withstand the voltage. Alternatively, use a voltage divider rated for the full 6-kv voltage, and multiply the ripple reading by the divider ratio.

Ripple on either the + 2-kv or − 2-kv supplies should not exceed 10 volts rms. All of the above ripple figures are for full-load conditions. If ripple or noise is found in excess of that given, check filtering circuit for malfunction. Oscillographic observation of waveforms at grid of driver tubes and power-amplifier tubes will be helpful in localizing, within the amplifier, the source of excessive hum, noise or distortion. In making tests of this sort, use caution in locating leads and test instruments, and keep them clear of high voltage points in the cabinet. Note that the convenience outlets inside the cabinet cannot be used unless switch 3S9 is temporarily jumpered, if the amplifier is to be operated.

4-9 DUMP CIRCUIT TESTING

If it is determined that repeated dumping is not due to troubles in the shaker or too sensitive a setting of dump-circuit shunt 11R36, or to overtravel in shaker, or to excessive transients in the input signal from console circuits, the trouble may exist in the armature-protector circuits. Proceed as follows:

a. Visually inspect the armature-protector chassis for signs of arcing or burning. Carefully check capacitors, for signs of cracks or damage, and insulators for excessive dust, cracks, loose connections, etc. Check bias voltages on the supplies biasing 11V4, 11V5 and 11V6; if VR tubes 11V3 and 11V7 are lit, the bias supplies are probably all right, although grid isolating resistors could still be open, or grid capacitors shorted. Check over load relay 3K11 for signs of arcing or burns; if found, clean and coat terminals with epoxy resin or Glyptal.

b. Substitute tubes 11V6, then 11V4 and 11V5, then 11V1 and 11V2 in that order, testing after each substitution. Allow sufficient warmup time (10 minutes) for new tubes.

c. If shutdown still occurs, remove plate leads from power amplifier tubes 3V9 and 3V10. If this cures shutdown difficulty, trouble is probably either gassy ML-5531 tubes or improper bias on these tubes.

d. If shutdown still occurs with 3V9 and 3V10 disconnected, turn off shaker field by opening circuit breaker, and remove plate caps from thyratrons, 11V4-5, then 11V1-2, in that order, testing after each removal. Then replace plate caps and unplug 11V6 from its socket. Some combination of these procedures should lead to solution of the difficulty. Frequent reference to the simplified schematic, Fig. 3-3, will be found helpful in trouble-shooting dump circuits.

4-10 CLEANING

High voltage attracts dust, an accumulation of which can cause flashovers and shutdowns. Interior of cabinets should be kept clean. Clean cabinets at least once every two months, using a tank-type vacuum cleaner. Household attachments such as are used for cleaning upholstery and reaching in cracks and corners will be helpful in reaching inaccessible places. Be careful in using vacuum-cleaner wands, to avoid striking fragile items such as tubes and insulators.

Air filters should be replaced when dirt becomes noticeable. Period of replacement depends on use, and how much dirt is in the intake air; six months is not unreasonable for fairly clean environments and sporadic usage, but filters may need replacing each month or every few weeks in very dusty locations and under heavy use. An excessive accumulation of dust inside cabinet is a reliable indication that filters should be replaced.

Clean interlocks and unsealed relay contacts only when absolutely necessary, and then only with a smooth burnishing tool. Do not use abrasives of any kind to clean contacts.

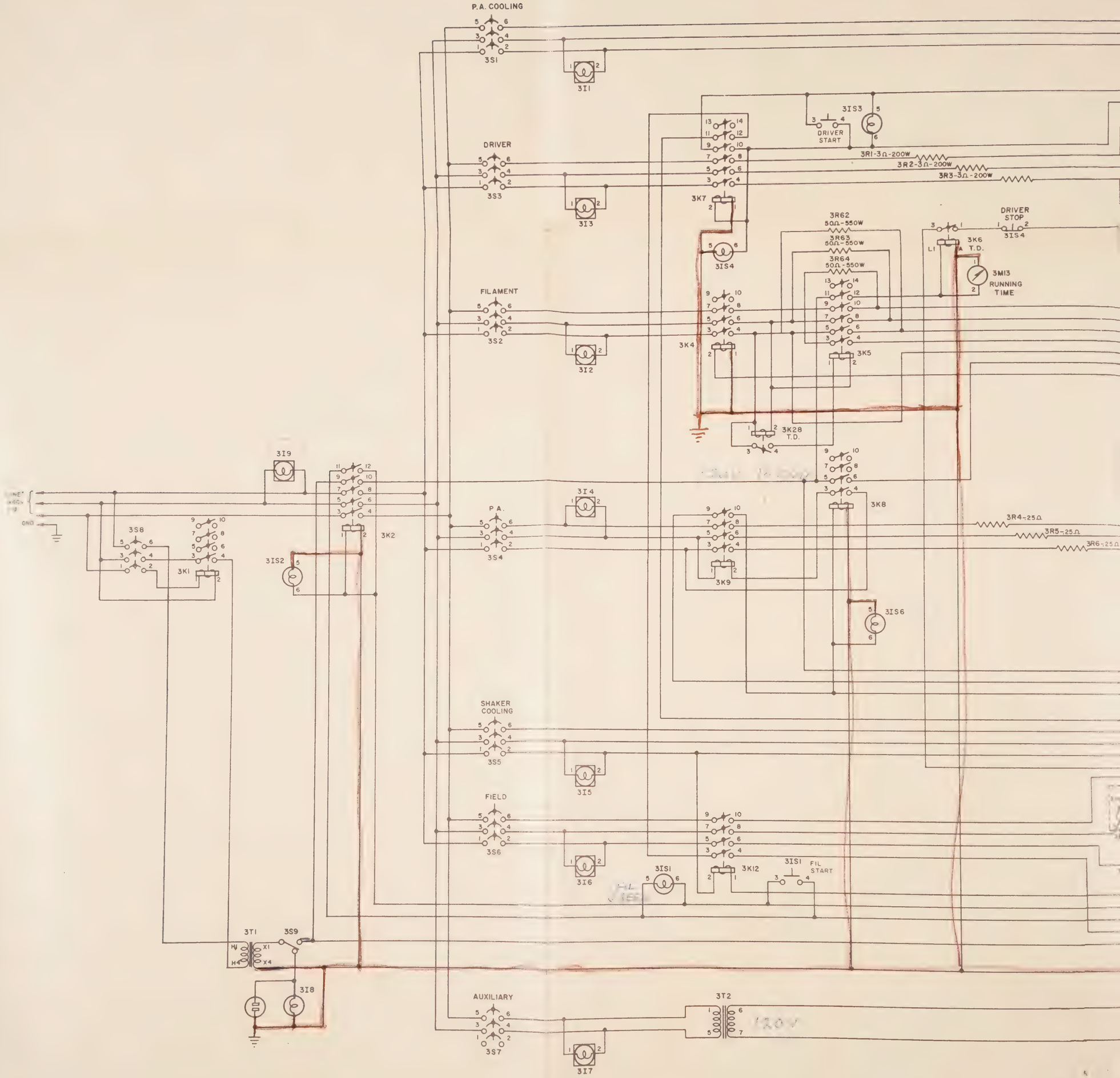
4-11 OILING

All blower bearings are sealed, bronze bearings, and do not need oiling or repacking at any time. There are no other moving parts in the Model PP-20/24 that require oiling, except that door hinges might be given an occasional drop of oil in humid climates where rust could be a problem.

4-12 OTHER DIFFICULTY

In the event of troubles or problems not covered by this manual, contact the factory giving serial number of amplifier, conditions of use, and full description of problem. Ling field service personnel are constantly available for consultation on special problems concerning utilization or application of Ling equipment, and upon making the necessary arrangements, can be on the scene within 24 hours.

SECTION 5
SCHEMATIC DIAGRAMS


P.A. COOLING
3S1
3I1
DRIVER
3S3
3I3
FILAMENT
3S2
3I2
P.A.
3S4
3I4
SHAKER COOLING
3S5
3I5
FIELD
3S6
3I6
AUXILIARY
3S7
3I7
3I9
3S8
3K1
3IS2
3K2
3I8
3T1
3S9
H1
H4
X1
X4
3IS3
DRIVER START
3R1-3Ω-200W
3R2-3Ω-200W
3R3-3Ω-200W
3K7
3IS4
3R62 50Ω-550W
3R63 50Ω-550W
3R64 50Ω-550W
DRIVER STOP
3IS4
3K6 T.D.
3MI3 RUNNING TIME
3K4
3K5
3K28 T.D.
3K8
3K9
3R4-25Ω
3R5-25Ω
3R6-25Ω
3IS6
3IS1
3K12
3IS1 FIL START
3T2
120V

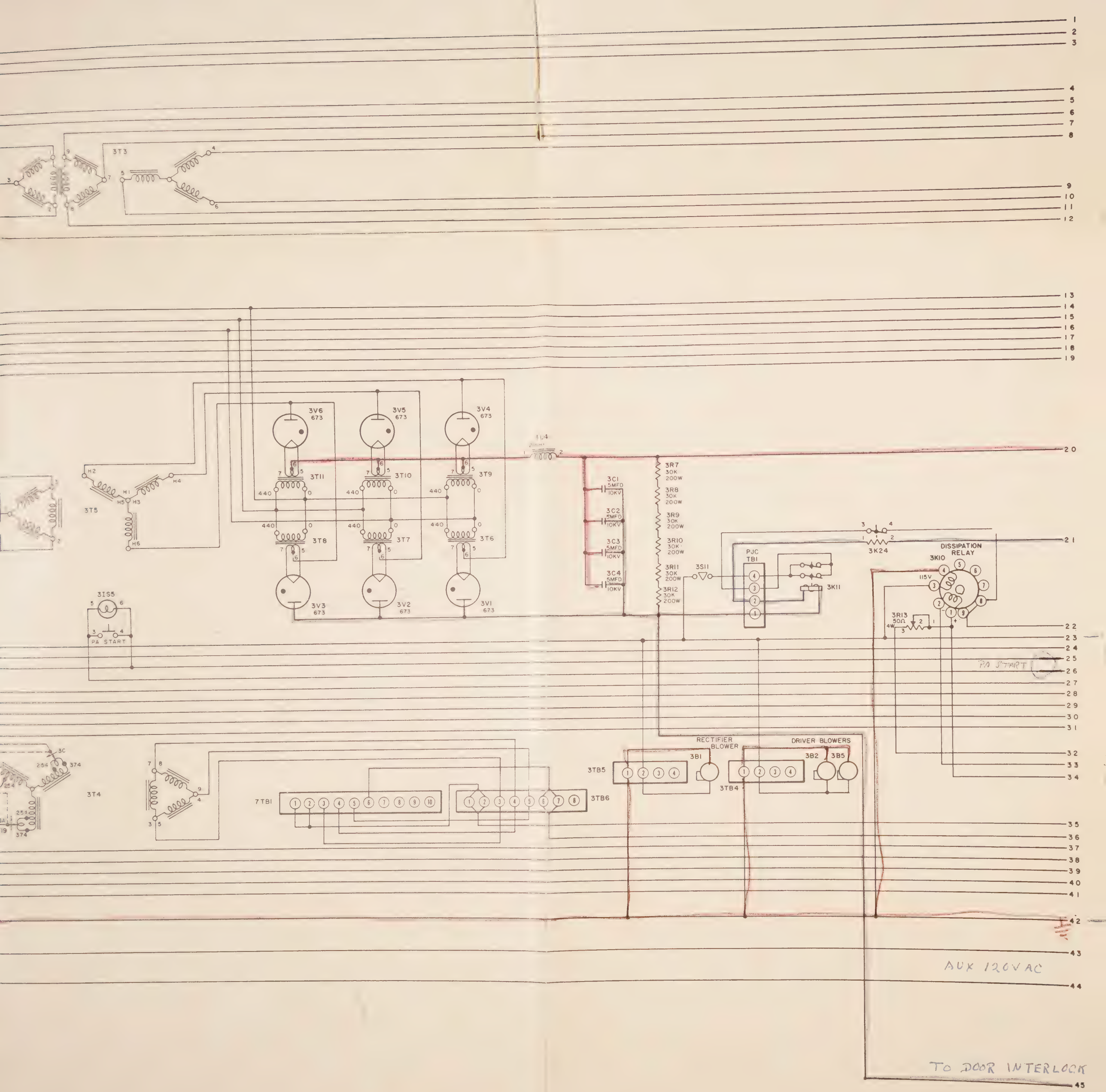
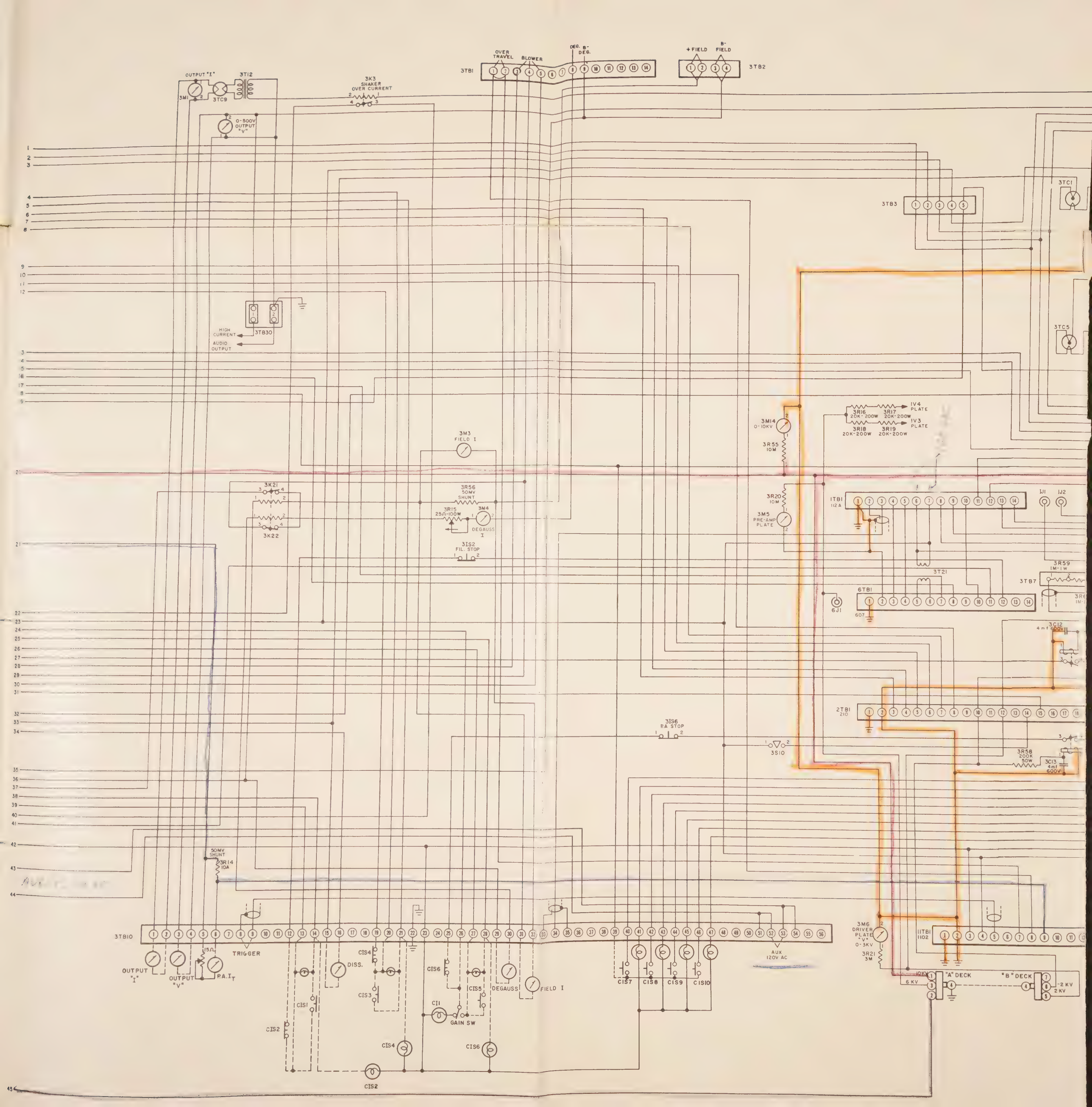


Figure 5-1. Power Supply, Schematic Diagram (Part 1 of 2).


OUTPUT "I"
3TI2
3MI
3TC9
0-500V OUTPUT "V"
3K3 SHAKER OVER CURRENT
3TBI
OVER TRAVEL
BLOWER
DEG.
B- DEG.
+FIELD
B- FIELD
3TB2
3TB3
3TCI
3TC5
HIGH CURRENT
AUDIO OUTPUT
3TB30
3M3 FIELD I
3K21
3K22
3R56 50MV SHUNT
3R15 25Ω-100W
3M4
DEGAUSS I
3IS2 FIL. STOP
3M14 0-10KV
3R55 10M
3R16 20K-200W
3R17 20K-200W
3R18 20K-200W
3R19 20K-200W
IV4 PLATE
IV3 PLATE
3R20 10M
3M5 PRE-AMP PLATE
ITBI 112A
IJI
IJ2
3T2I
3TB7
3R59 IM-1W
6TBI
6JI
607
3C12 4 mf 600V
2TBI 210
3IS6 PA STOP
3SI0
3R58 200K 50W
3C13 4 mf 600V
50MV SHUNT
3R14 10A
3TBIO
TRIGGER
OUTPUT "I"
OUTPUT "V"
15Ω
P.A.I T
DISS.
CIS1
CIS2
CIS3
CIS4
CIS5
CIS6
CII
GAIN SW
DEGAUSS
FIELD I
CIS7
CIS8
CIS9
CIS10
AUX 120V AC
3M6 DRIVER PLATE "V" 0-3KV
3R21 3M
IITBI 1102
10KV
6 KV
"A" DECK
"B" DECK
-2 KV
2 KV

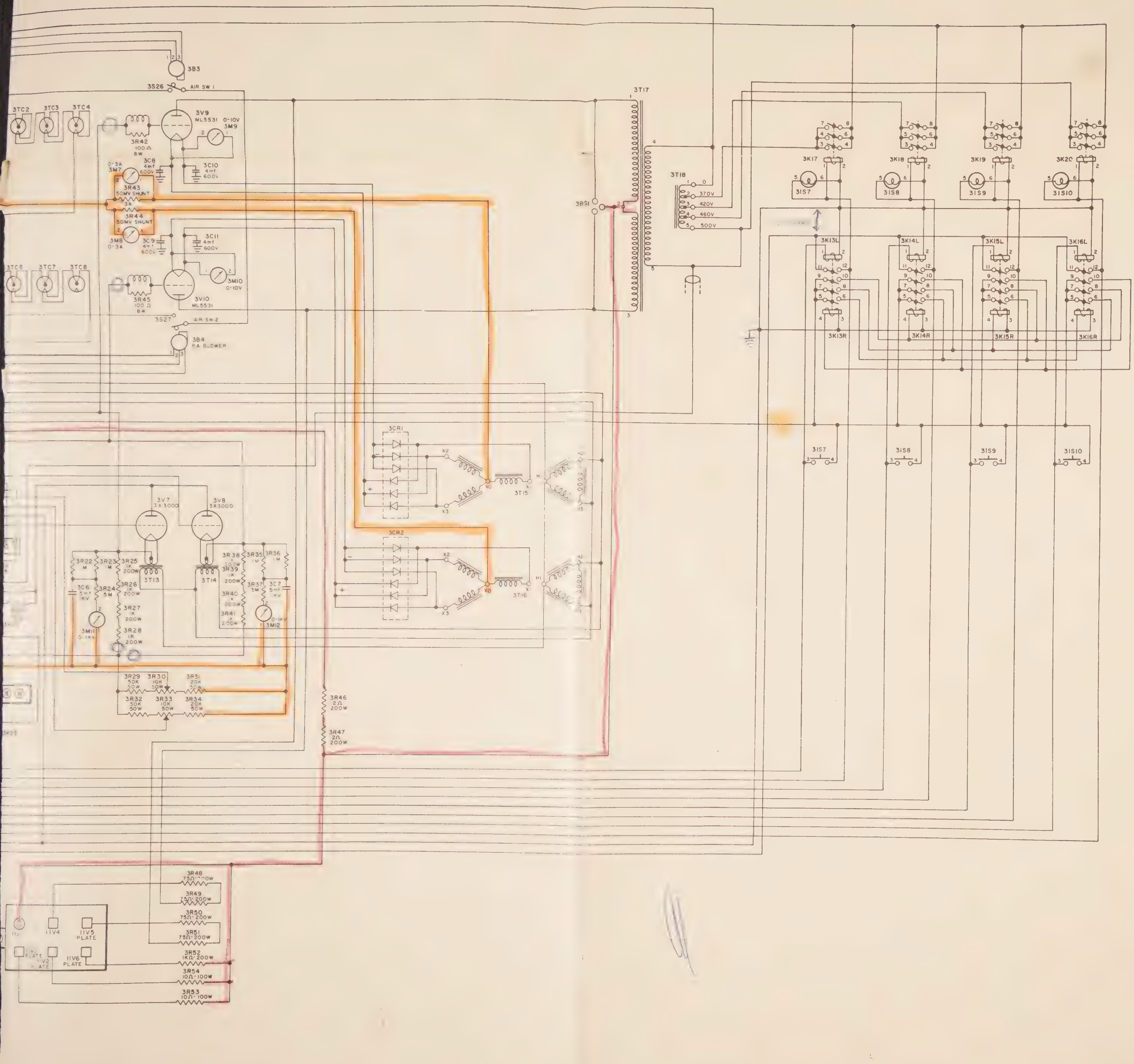
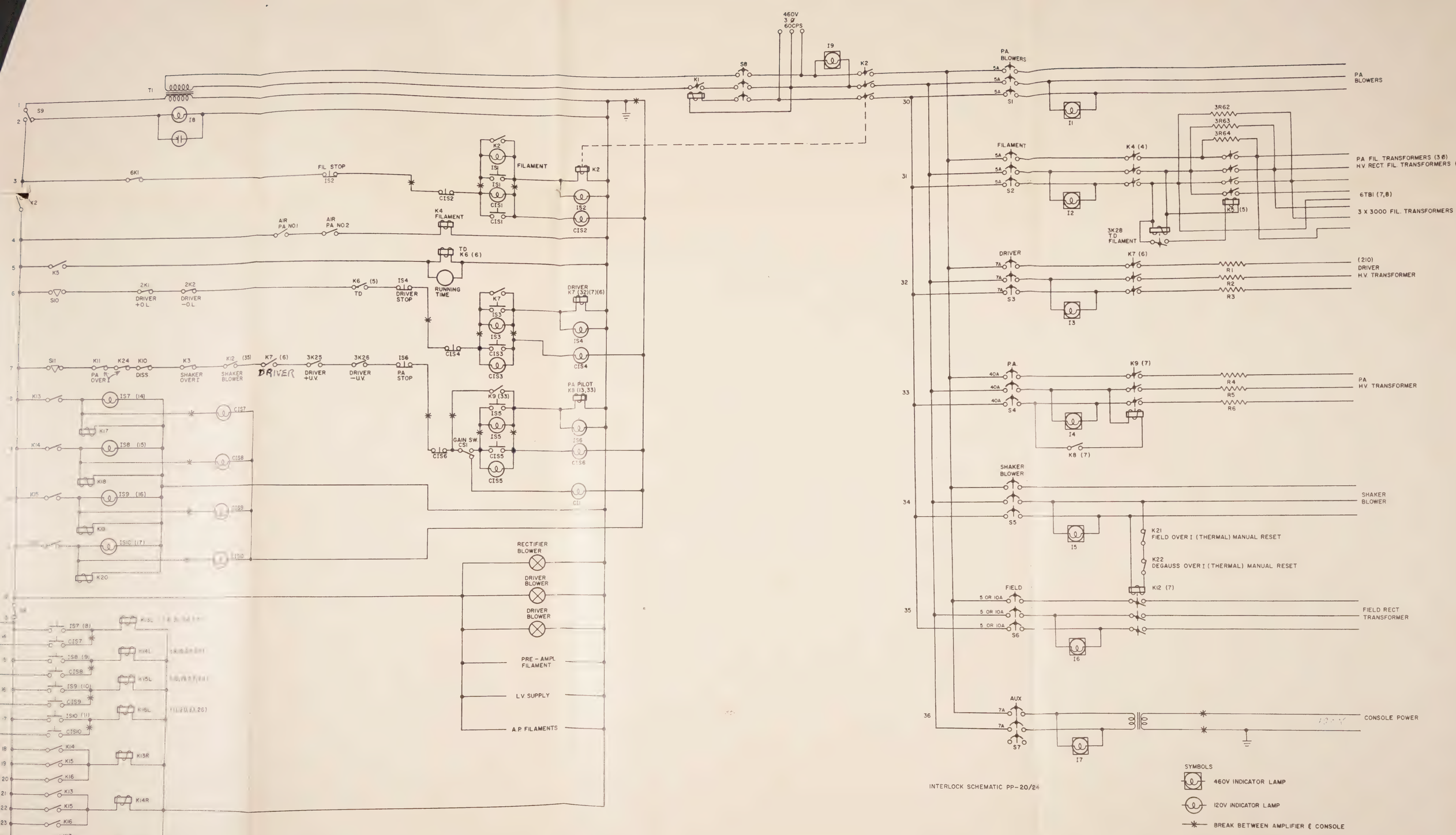


Figure 5-1. Power Supply, Schematic Diagram (Part 2 of 2).



INTERLOCK SCHEMATIC PP-20/24

Figure 5-2. Interlock Circuit, Schematic Diagram.

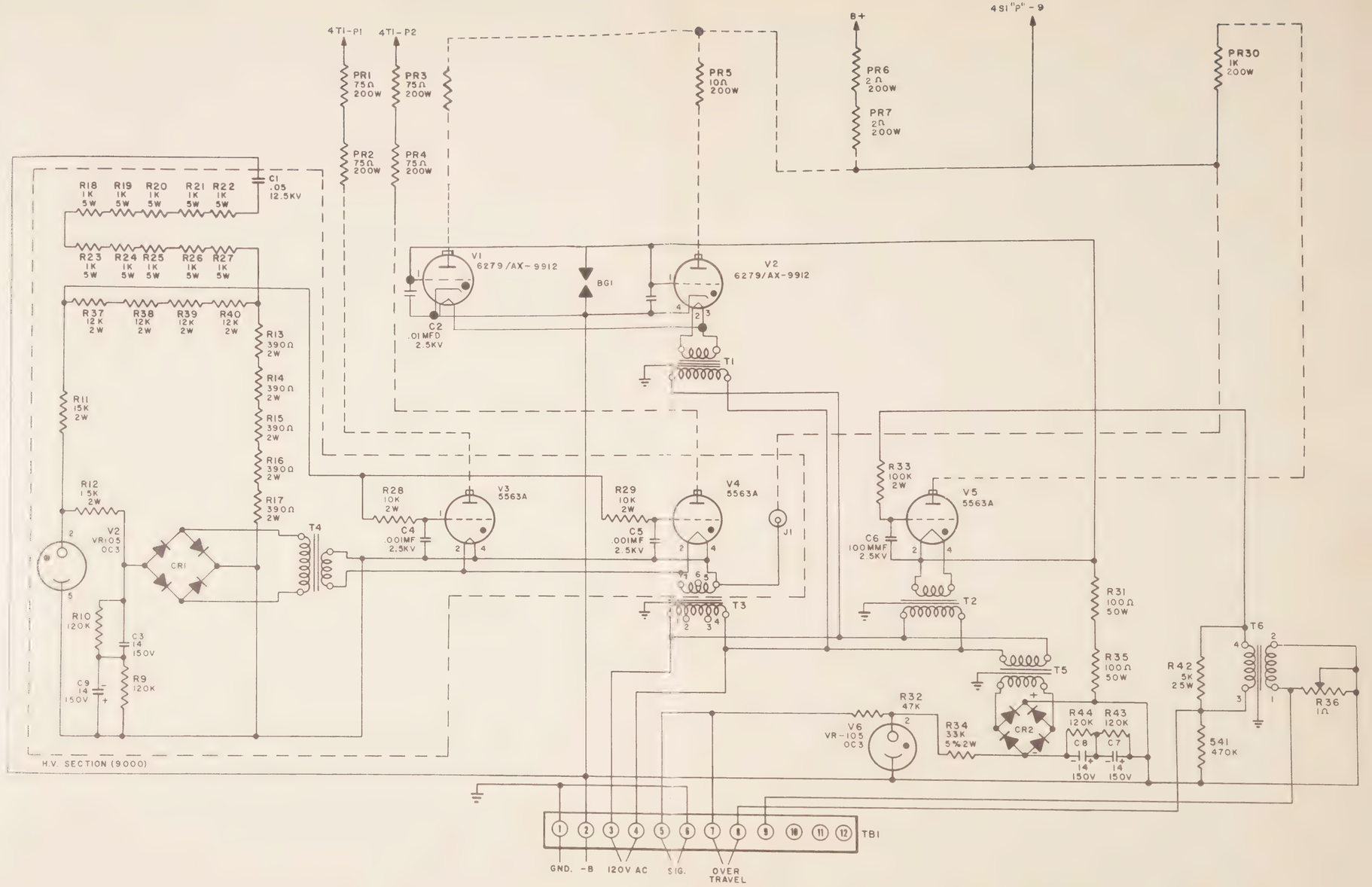


Figure 5-4. Model 1102 Armature Protector, Schematic Diagram.

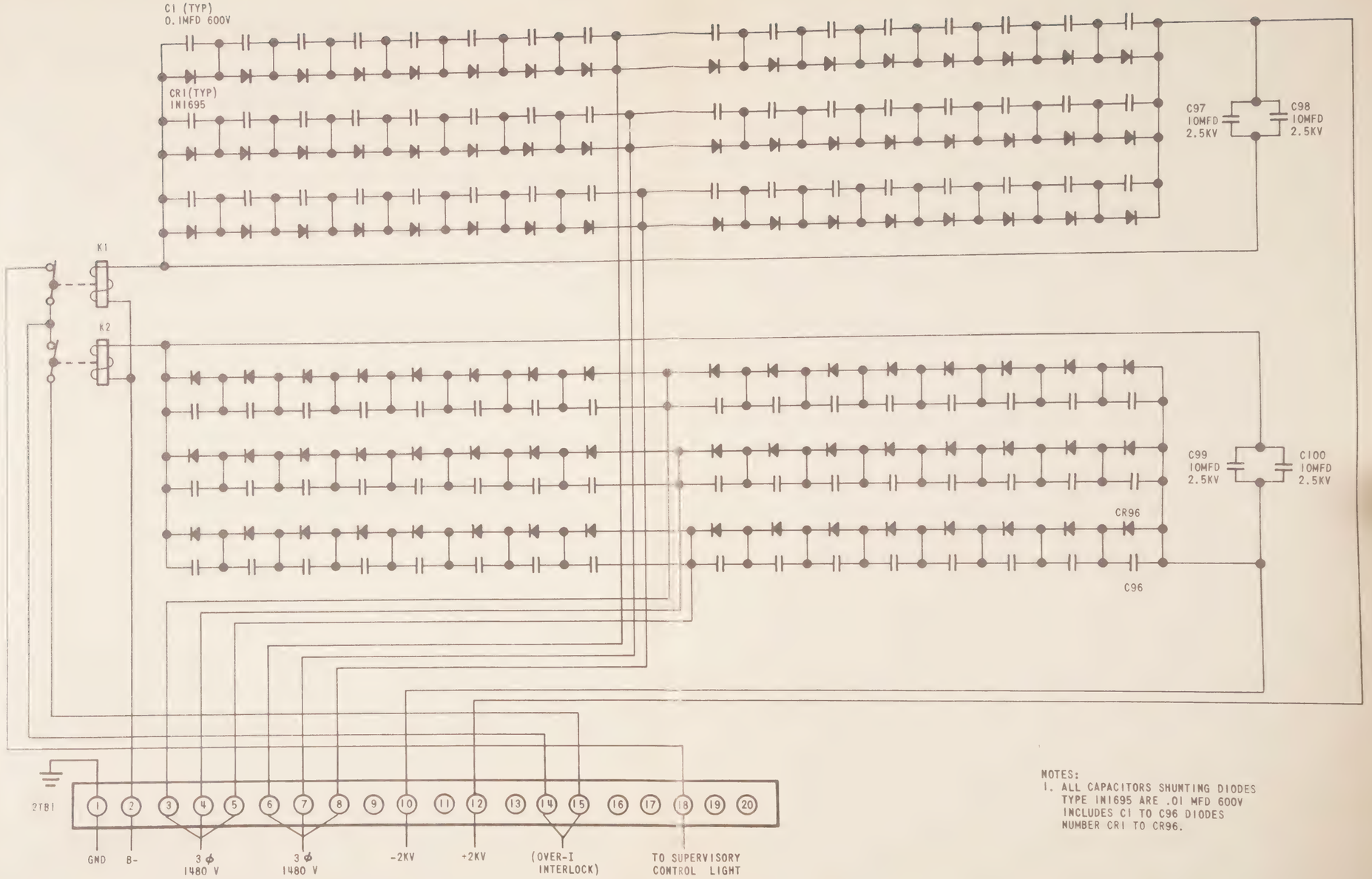


Figure 5-5. Model 210A Driver Power Supply, Schematic Diagram.

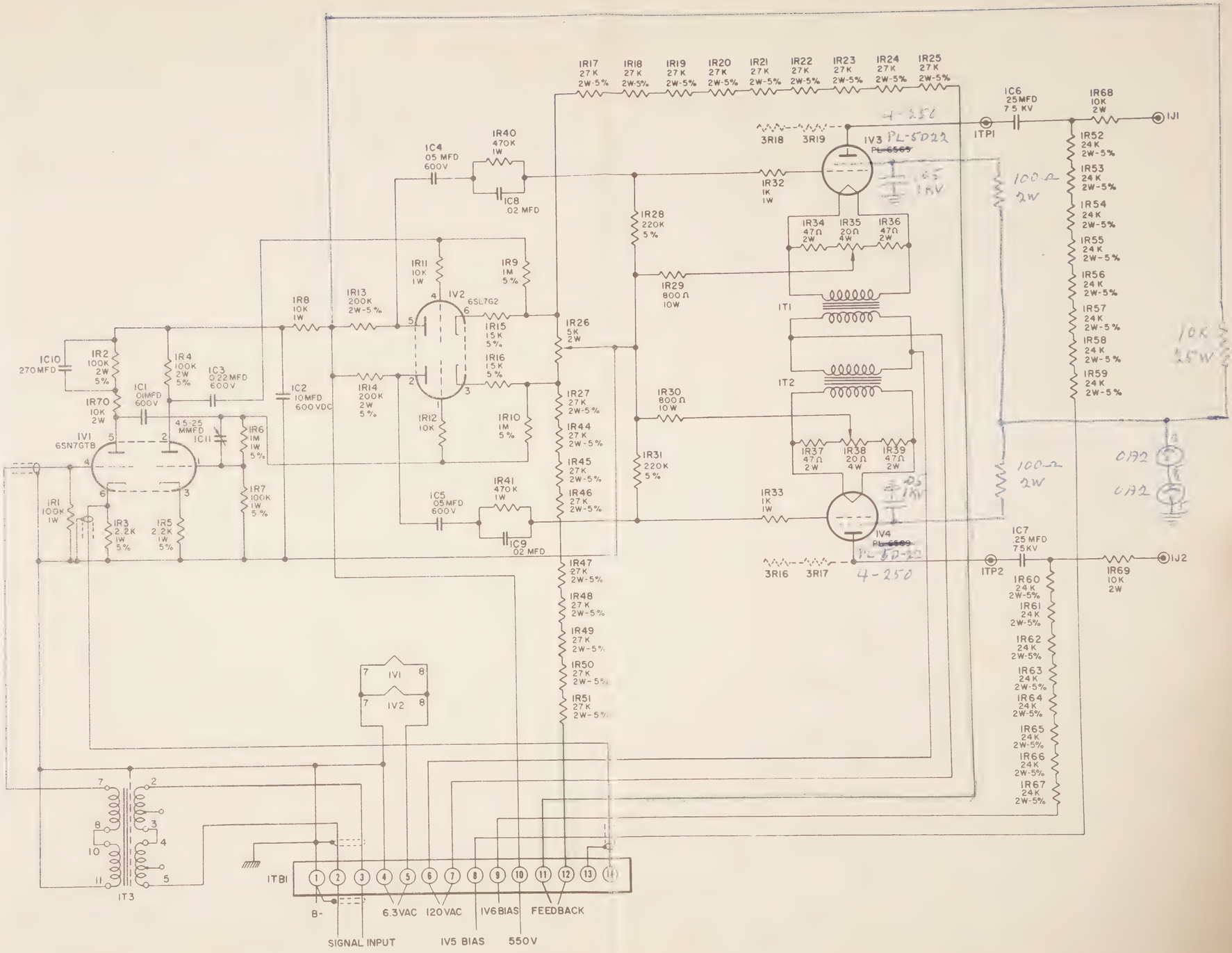


Figure 5-6. Model 112A Pre-Amplifier, Schematic Diagram.

SECTION 6
REPLACEABLE PARTS LIST

COMPONENTS

320 CUBICLE

112A CHASSIS PREAMPLIFIER

210A CHASSIS DRIVER POWER SUPPLY

607 CHASSIS PREAMPLIFIER POWER SUPPLY

1102 CHASSIS ARMATURE PROTECTOR

CIRCUIT REF. NO.	DESCRIPTION OF PARTS		MANUFACTURER
3B1	Blower		Dayton Electric
3B2	Blower	112 Chassis, Type 2C610	Dayton Electric
3B3	Blower housing	3/4 hp motor	General Electric
3B4	Blower housing	3/4 hp motor	General Electric
3B5	Blower	112 Chassis, Type 2C610	Dayton Electric
3C1	Capacitor	9-mfd, 7.5-kv, 14F422	General Electric
3C2	Capacitor	9-mfd, 7.5-kv, 14F422	General Electric
3C6	Capacitor	0.5-mfd, 1-kv, 23F473	General Electric
3C7	Capacitor	0.5-mfd, 1-kv, 23F473	General Electric
3C8	Capacitor	4-mfd, 600-v, P-30-2	Aerovox
3C9 thru 3C11	Capacitor	4-mfd, 600-v, P-30-2	Aerovox
3C12	Capacitor	4-mfd, 600-v, 23F351-G102	General Electric
3C13	Capacitor	4-mfd, 600-v, 23F351-G102	General Electric
3CR1	Rectifier, silicon	136 amp, 50-v piv, 4JA6011FF1AB1	General Electric
3CR2	Rectifier, silicon	136 amp, 50-v piv, 4JA6011FF1AB1	General Electric
3CR3	Rectifier, silicon	6 amp, 200-v piv, 4JA211BB1AC3	General Electric
3I1	Indicator light, PA blowers, heavy duty, oil tight indicator light, transformer type, 480/115v front mounting candelabra, 6S6 lamp, 115 to 125v 6W, Green	CR-2940-UE21264	General Electric

CIRCUIT REF. NO.	DESCRIPTION OF PARTS		MANUFACTURER
312	Indicator light, filament heavy duty, oil tight indicator light, transformer type, 480/115v, front mounting candelabra, 6S6 lamp, 115 to 125v 6W, Green	CR-2940-UE212C4	General Electric
313	Indicator light, driver, heavy duty, oil tight indicator light, transformer type, 480/115-v, front mounting candelabra, 6S6 lamp, 115 to 125-v, 6W, Green	CR-2940 UE212C4	General Electric
314	Indicator light, PA, heavy duty, oil tight indicator light, transformer type, 480/115-v, front mounting candelabra, 6S6 lamp, 115 to 125-v 6W, Green	CR-2940-UE212C4	General Electric
315	Indicator light, shaker blower, heavy duty, oil tight indicator light, transformer type, 480/115-v, front mounting candelabra, 6S6 lamp, 115 to 125-v 6W, Green	CR-2940-UE212C4	General Electric
316	Indicator light, auxiliary, heavy duty, oil tight indicator light, transformer type, 480/115-v, front mounting candelabra, 6S6 lamp, 115 to 125-v 6W, Green	CR-2940-UE212C4	General Electric

CIRCUIT REF. NO.	DESCRIPTION OF PARTS		MANUFACTURER
317	Indicator light, auxiliary heavy duty, oil tight indicator light, transformer type, 480/115-v, front mounting candelabra, 6S6 lamp, 115 to 125-v 6W, green	CR-2940-UE212C4	General Electric
318	Light cubicle, 115-v 60W		
319	Indicator light, line, heavy duty, oil tight indicator light, transformer type, 480/115-v, front mounting candelabra, 6S6 lamp, 115 to 125-v 6W, green	CR-2940-UE212B4	General Electric
31S1	Indicator-illuminated pushbutton, filament start, green, heavy duty, contact current 10 amp 600-v, oil tight transformer type, 110 to 6.3-v with No. 12 G.E. lamp	CR-2940-UW221C2	General Electric
31S2	Indicator-illuminated filament start, pushbutton, red, heavy duty, contact current 10 amp 600-v, oil tight transformer type, 110 to 6.3-v with No. 12 G.E. lamp	CR-2940-UW221B2	General Electric
31S3	Indicator-illuminated pushbutton, driver start, green, heavy duty, contact current 10 amp 600-v, oil tight transformer type, 110 to 6.3-v with No. 12 G.E. lamp	CR-2940-UW221B2	General Electric

CIRCUIT REF. NO.	DESCRIPTION OF PARTS		MANUFACTURER
3IS4	Indicator-illuminated pushbutton, driver stop, red, heavy duty, contact current 10 amp 600-v, oil tight transformer type, 110 to 6.3-v with No. 12 G.E. lamp	CR-2940-UW221B2	General Electric
3IS5	Indicator-illuminated pushbutton, PA start, green, heavy duty, contact current 10 amp 600-v, oil tight transformer type, 110 to 6.3-v with No. 12 G.E. lamp	CR-2940-UW221C2	General Electric
3IS6	Indicator-illuminated pushbutton, PA stop, red, heavy duty, contact current 10 amp 600-v, oil tight transformer type, 110 to 6.3-v with No. 12 G.E. lamp	CR-2940-UW221B2	General Electric
3IS7	Indicator-illuminated pushbutton, impedance selector, white, heavy duty, contact current 10 amp 600-v, oil tight transformer type, 110 to 6.3-v with No. 12 G.E. lamp	CR-2940-UW221F2	General Electric
3IS8 thru 3IS10	Same as 3IS7		
3K1	Relay, control PM enclosed, 10 amp 600-v, four normally open contacts, 440-v coil	5A4-46	Clark Controller

CIRCUIT REF. NO.	DESCRIPTION OF PARTS		MANUFACTURER
3K2	Relay, contactor, size 3 enclosed, 90 amp 600-v, three normally open main contacts, two normally open contacts, two normally open auxiliary contacts, 110-v coil	77A33-16	Clark Controller
3K3	Relay, shaker over-current, thermal overload, heater 81D589, 53 to 58 amps	CR-2824-42B	General Electric
3K4	Relay, filament, 10 amp 600-v, four normally open contacts, four normally closed contacts, 110-v coil	5UU4-16	Clark Controller
3K5	Relay, filament, 10 amp 600-v, six normally open contacts, six normally closed contacts, 440-v coil	5UU6-46	Clark Controller
3K6	Relay, time delay, 27 min	HD-32A623	Eagle Signal
3K7	Relay, driver, 10 amp 600-v, six normally open contacts, six normally closed contacts, 110-v coil	5UU6-16	Clark controller
3K8	Same as 3K4		
3K9	Relay, plate supply, size 2, 50 amp, three normally open contacts, 440-v coil	77U32-46	Clark Controller
3K10	Relay, dissipation, contacts normally closed, 5-mv coil	2304-SRH	Assembly Products

CIRCUIT REF. NO.	DESCRIPTION OF PARTS		MANUFACTURER
3K11	Relay, PA over-current, self reset contacts, 4 to 16 amps	12PJC11A4	General Electric
3K12	Relay, field, size 2, 50 amp three normally open contacts, 440-v coil	77U32-46	Clark Controller
3K13 thru 3K16	Relay, latching, four normally open contacts, four normally closed contacts, 110-v coil	5UUH4-16	Clark Controller
3K17 thru 3K20	Relay, latch, size 1, 30 amp, three normally open contacts, 120-v coil	77U31-16	Clark Controller
3K21	Relay, thermal, field 27.3 to 30 amps, over-current, heater 81D582	CR-2824-42D	General Electric
3K22	Relay, thermal, degauss over-current, 1.03 amps, heater CR-123-C1.09A	CR-124-C028	General Electric
3K24	Relay, thermal, PA over current, 3.13 amps, heater CR-124-C3.26A	CR-124-C028	General Electric
3K25 thru 3K26	Relay, AH series, 10 amps 110-vac, 220-v coil	AH2C	Advance Electric and Relay
3K28	Relay, time delay, 0.2 sec to 3 min. one contact normally open, one contact normally closed, 440-v coil	713UPA-46	Clark Controller
3L4	Choke, 0.213-h at 3.15 amp, 42-kv rms, 5.1-ohms		Crittenden Transformer

CIRCUIT REF. NO.	DESCRIPTION OF PARTS		MANUFACTURER
3M1	Meter, output current, 0 to 5 amp, external thermocouple (calibrated 0-100A)	RT-37	Westinghouse
3M2	Meter, output voltage, 500-vac	RC-37	Westinghouse
3M3	Meter, field current		
3M4	Meter, degauss current		
3M5	Meter, plate voltage, pre-amplifier 1-ma (calibrated 0-10K-vdc)	RX-35	Westinghouse
3M6	Meter plate voltage, driver (calibrated 0-3K-vdc) 1-ma	RX-37	Westinghouse
3M7	Meter, plate current, power amplifier - 1, 50-mv shunt (calibrated 0-3A d-c)	RX-37	Westinghouse
3M8	Meter, plate current, power amplifier - 2, 50-mv shunt (calibrated 0-3A d-c)	RX-37	Westinghouse
3M9	Meter, filament 1, power amplifier, 0-10-v	RX-35	Westinghouse
3M10	Meter, filament 2, power amplifier, 0-10-v	RX-35	Westinghouse
3M11	Meter, bias 1, power amplifier, 1-ma, (calibrated 0-1K vdc)	RX-35	Westinghouse
3M12	Meter, bias 2, power amplifier, 1-ma, (calibrated 0-1K vdc)	RX-35	Westinghouse
3M12	Meter, running time	RH-35	Westinghouse

CIRCUIT REF. NO.	DESCRIPTION OF PARTS		MANUFACTURER
3MI4	Meter, PA plate volts I-ma, (calibrated 0-10-kv)	RX-37	Westinghouse
3RI	Resistor, 3-ohm 200W ferrule D core	Type 314	Ward-Leonard
3R2 thru 3R3	Same as 3RI		
3R4	Resistor, 0.25-ohm, 36 amp, "Edgeohm" ribbon wound, oval core	37086	Ward-Leonard
3R5 thru 3R6	Same as 3R4		
3R7	Resistor, 30K, 200W, ferrule D core	Type 314	Ward-Leonard
3R8 thru 3RI2	Same as 3R7		
3RI3	Resistor, variable, 50-ohm, 4W wirewound, 275 degree rotation	M50PK	Mallory
3RI4	Resistor, 50-mv shunt, ± 0.25 % 10A, type G	724756	Westinghouse
3RI5	Resistor, variable, See appropriate field supply (for power supply 177 use 25-ohm, 100W, Ohmite No.0448)		
3RI6	Resistor, 20K ± 5 %, 200W, ferrule D core	Type 314	Ward-Leonard
3RI7 thru 3RI9	Same as 3RI6		

CIRCUIT REF. NO.	DESCRIPTION OF PARTS		MANUFACTURER
3R20	Resistor, meter multiplier, 10 meg ± 5 %, 10-kv, 1- a max current (1 meg multiple sections)		Westinghouse
3R21	Resistor, meter multiplier, 3 meg ± 0.5 %, 3-kv, 1-ma max. current		Westinghouse
3R22	Resistor, meter multiplier, 1 meg ± 0.5 %, 1-kv, 1-ma max. current		Westinghouse
3R23	Same as 3R22		
3R24	Resistor, meter multiplier, 500K ± 0.5 %, 500-v, 1-ma max. current		Westinghouse
3R25	Resistor, 1K, 200W, ferrule D core	Type 314	Ward-Leonard
3R26 thru 3R28	Same as 3R25		
3R29	Resistor, 50K, 50W, ferrule D core	Type 314	Ward-Leonard
3R30	Resistor, variable, 10K, 50W wirewound, rheostat, 300 degree rotation	0332	Ohmite
3R31	Resistor, 20K, 50W, ferrule D core	Type 314	Ward-Leonard
3R32	Same as 3R29		
3R33	Same as 3R30		
3R34	Same as 3R31		

CIRCUIT REF. NO.	DESCRIPTION OF PARTS		MANUFACTURER
3R35 and 3R36	Resistor, meter multiplier, 1 meg ± 0.5 %, 1-kv, 1-ma max. current		Westinghouse
3R37	Resistor, meter multiplier, 500K ± 0.5 %, 500-v, 1-ma max. current		Westinghouse
3R38 thru 3R41	Resistor, 1K, 200W, ferrule D core	Type 314	Ward-Leonard
3R42	Resistor, parasitic suppressor, 100-ohm ± 10 %, 8W, wirewrap carborundum "Glowbar"		Gates Radio Co.
3R43 and 3R44	Resistor, 50-mv shunt, ± 0.25 %, 3A, type G, temperature error less than 0.2 % from 24 to 80 degrees cent.	936941	Westinghouse
3R45	Same as 3R42		
3R46 and 3R47	Resistor, 2-ohm, 200W, ferrule D core	Type 314	Ward-Leonard
3R48 and 3R51	Resistor, 75-ohm, 200W, ferrule D core	Type 314	Ward-Leonard
3R52	Resistor, 1K, 200W, ferrule D core	Type 314	Ward-Leonard
3R53 and 3R54	Resistor, 10-ohm, 200W, ferrule D core	Type 314	Ward-Leonard

CIRCUIT REF. NO.	DESCRIPTION OF PARTS		MANUFACTURER
3R55	Resistor, meter multipler, 10 meg, ± 0.5 %, 10-kv, 1-ma max. current (1 meg multiple sections)		Westinghouse
3R56	Resistor, shunt, See appropriate field supply (for power supply 177 use 50-mv 50adc)	703928	Westinghouse
3R57 and 3R58	Resistor, 200K, 50W, ferrule D core	Type 314	Ward-Leonard
3R59 and 3R60	Resistor, 1 meg ± 10 %, 1W, deposited carbon		Ohmite
3R62 thru 3R64	Resistor, 50-ohm, ± 10 %, 550W	Ribflex	Ward-Leonard
3S1	Switch, breaker, PA blowers, 3 pole common trip, back connected 5A at 460 vac	3363S-5-460, VAC-1	Heinemann
3S2	Switch,breaker, filament, 3 pole companion trip, back connected, 7A at 460 vac	3X1163S-7-460, VAC-1	Heinemann
3S3	Switch, breaker, driver, 3 pole common trip, back connected, 5A at 460-vac	3363S-5-460, VAC-3	Heinemann
3S4	Switch, breaker, PA, 3 pole companion trip, back connected, 40A at 460-vac	3X1163S-40-460, VAC-3	Heinemann
3S5	Switch, breaker, shaker blower, 3 common trip, back connected, 3A at 460-vac	3363S-3-460, VAC-1	Heinemann

CIRCUIT REF. NO.	DESCRIPTION OF PARTS		MANUFACTURER
3S6	Switch, breaker, field, see appropriate field supply (for power supply 177 use 3 pole common trip, back connected, 10A at 460-vac)	3X1163S-10-460	Heinemann
3S7	Switch, breaker, auxiliary, 3 pole common trip, back connected, 7A at 460-vac	3363S-7-460, VAC-1	Heinemann
3S8	Switch, breaker, control enclosed, 3 pole common trip, 5A at 460-vac	3363G1-5-460, VAC-1	Heinemann
3S9	Switch, heavy duty, door 20A at 460-vac	3ML1	Micro Switch
3S10 and 3S11	Switch, door interlock, V type, contacts 5A	7460-330-G4	General Electric
3S24 and 3S25	Switch, HV shorting, 2 deck, 10-kv (large)	S-100-2	Stagnaro
3S26 and 3S27	Switch, airflow, vane-operated SPDT, 5A at 250-vac	2A-2450	Rotron
3T1	Transformer, control; pri 480-vac, 60-cps, sec 120/240-vac, 1.5-kva, 25 % FCBN taps in pri	9T51Y-6675	General Electric
3T2	Transformer, auxiliary, pri 480-vac, 60-cps, sec 120-vac, 2.5-kv rms test	3187	Wahlgren

CIRCUIT REF. NO.	DESCRIPTION OF PARTS		MANUFACTURER
3T3	Transformer, terminals 1-2-3 480-vac, 60-cps, 5.2A/ϕ, 4320-va, terminals 4-5-6 885 VP/L, 1481 VL-L, 0.819A, rms 4000WV. 1 % output tolerance between secondaries, ± 3 % output voltage tolerance, hermetically sealed	4051	Wahlgren
3T4	Transformer, see appropriate field supply (for power supply 177 use pri 254 and 374-v taps, 60-cps, sec 185-v, 24.95A per line; pri capacity 9.8-kva, sec capacity 8.0-kva	10112	Crittenden
3T5	Transformer, plate; delta pri, taps 420, 440, 460, and 500-vac, 60-cap; wye sec 3850/6660-vac, 2.6A, 30-kva	10001	Crittenden
3T6 thru 3T11	Transformer, filament; pri taps 440, 460 and 480-vac, 50 to 60-cps; sec 5-vac, center-tapped, 10A	9045	Wahlgren
3T12	Transformer, current, 100/5A, error 0 % at 30 % of rated current, 0.5 % at 150 % rated current	1243539	Westinghouse
3T13 thru 3T14	Transformer, filament, pri taps 440, 460 and 480-vac, 60-cps; sec 7.5-vac, center-tapped; 51A with 1.5A at center-tap	3980	Wahlgren
3T15 thru 3T16	Transformer, filament, pri 440-vac, 3 ϕ 60-cps, (delta to wye); sec 6.3-vac at 92A	10084	Crittenden

CIRCUIT REF. NO.	DESCRIPTION OF PARTS		MANUFACTURER
3T17	Transformer, output, first stage; 20-kva, pri 11.5-kv rms center-tapped, 20 to 5KC; Sec 500-v (no load volts); Cont. duty; DC plate voltage 9-kv, DC plate current 1.6A per tube	E-11201	Electro Engrg.
3T18	Transformer, output, second stage; autotransformer; taps 500-v, 460-v, 420-v and 370-v rms	E-11202	Electro Engrg.
3T19	Transformer, variac, see appropriate field supply (for power supply 177 use 3 gang V-10 variac, 110-v, 10A, 1.5-kva;	C-1063	General Radio
3V1 thru 3V6	Tube, electron, rectifier	Type 673	Radio Corp of America
3V7 thru 3V8	Tube, electron, driver	Type 3X3000F1	Eimac
3V9	Tube, elecron, power output	Type ML-5531	Machlett
3V10	Same as 3V9		

112A PREAMPLIFIER AND DRIVER CHASSIS

1C1	Capacitor	.01-mfd, 600-v, 111-6S1	Pyramid
1C2	Capacitor	10-mfd, 600-v, 23F878	General Electric
1C3	Capacitor	.22-mfd, 600-v, 111-6S5	Pyramid
1C4	Capacitor	.05-mfd, 600-v, 111-6S5	Pyramid

CIRCUIT REF. NO.	DESCRIPTION OF PARTS		MANUFACTURER
IC5	Capacitor	.05-mfd, 600-v, 11-6S5	Pyramid
IC6	Capacitor	.25-mfd, 7.5-kv, 23F426-G103	General Electric
IC7	Capacitor	.25-mfd, 7.5-kv, 23F426-G103	General Electric
IC8	Capacitor	.02-mfd, 600-v, BYB-6S2	Cornell-Dubilier
IC9	Capacitor	.02-mfd, 600-v, BYB-6S2	Cornell-Dubilier
IC10	Capacitor	270-mmfd, 600-v, LIDT27	Cornell-Dubilier
IC11	Capacitor	4.5-25-mmfd, 600-v, CU11A250	Erie
IR1	Resistor	82K, 1W	Ohmite
IR2	Resistor	100K, 2W, 5 %	Ohmite
IR3	Resistor	2.2K, 1W, 5 %	Ohmite
IR4	Resistor	100K, 2W, 5 %	Ohmite
IR5	Resistor	2.2K, 1W, 5 %	Ohmite
IR6	Resistor	1 meg, 1W, 5 %	Ohmite
IR7	Resistor	100K, 1W, 5 %	Ohmite
IR8	Resistor	10K, 1W, 5%	Ohmite
IR9	Resistor	1 meg, 1W, 5 %	Ohmite
IR10	Resistor	1 meg, 1W, 5%	Ohmite
IR11	Resistor	10K, 1W, 10 %	Ohmite
IR12	Resistor	10K, 1W, 10 %	Ohmite
IR13	Resistor	200K, 2W, 5 %	Ohmite
IR14	Resistor	200K, 2W, 5 %	Ohmite
IR15	Resistor	1.5K, 1W, 5 %	Ohmite
IR16	Resistor	1.5K, 1W, 5 %	Ohmite

CIRCUIT REF. NO.	DESCRIPTION OF PARTS		MANUFACTURER
IR17	Resistor	27K, 2W, 5 %	Ohmite
IR18	Resistor	27K, 2W, 5 %	Ohmite
IR19	Resistor	27K, 2W, 5 %	Ohmite
IR20	Resistor	27K, 2W, 5 %	Ohmite
IR21	Resistor	27K, 2W, 5 %	Ohmite
IR22	Resistor	27K, 2W, 5 %	Ohmite
IR23	Resistor	27K, 2W, 5 %	Ohmite
IR24	Resistor	27K, 2W, 5 %	Ohmite
IR25	Resistor	27K, 2W, 5 %	Ohmite
IR26	Potentiometer	5K, 2W, CLU 5021	Ohmite
IR27	Resistor	27K, 2W, 5 %	Ohmite
IR28	Resistor	220K, 1W, 5 %	Ohmite
IR29	Resistor	800-ohm, 10W	
IR30	Resistor	800-ohm, 10W	
IR31	Resistor	220K, 1W, 5%	
IR32	Resistor	1K, 1W, 10 %	
IR33	Resistor	1K, 1W, 10 %	
IR34	Resistor	47-ohm, 2W, 5 %	
IR35	Resistor	20-ohm, 4W, M20PK	Mallory
IR36	Resistor	47-ohm, 2W, 5 %	Ohmite
IR37	Resistor	47-ohm, 2W, 5 %	Ohmite
IR38	Resistor	20-ohm, 4W, M20PK	Mallory

CIRCUIT REF. NO.	DESCRIPTION OF PARTS		MANUFACTURER
1R39	Resistor	47-ohm, 2W, 5 %	Ohmite
1R40	Resistor	470K, 1W, 10 %	Ohmite
1R41	Resistor	470K, 1W, 10 %	Ohmite
1R44	Resistor	27K, 2W, 5 %	Ohmite
1R45	Resistor	27K, 2W, 5 %	Ohmite
1R46	Resistor	27K, 2W, 5 %	Ohmite
1R47	Resistor	27K, 2W, 5 %	Ohmite
1R48	Resistor	27K, 2W, 5 %	Ohmite
1R49	Resistor	27K, 2W, 5 %	Ohmite
1R50	Resistor	27K, 2W, 5 %	Ohmite
1R51	Resistor	27K, 2W, 5 %	Ohmite
1R52	Resistor	24K, 2W, 5 %	Ohmite
1R53 thru 1R67	Resistor	24K, 2W, 5 %	Ohmite
1R68 thru 1R70	Resistor	10K, 2W, 10 %	Ohmite
1TB1	Terminal board	14-142	Cinch-Jones
1T1	Transformer - filament	F-11U	Triad
1T2	Transformer	F-11U	Triad
1T3	Transformer - input	No. 15149	Peerless
1V1	Tube	6SN7GTB	R.C.A.

CIRCUIT REF. NO.	DESCRIPTION OF PARTS		MANUFACTURER
IV2	Tube	6SL7GT	R.C.A.
IV3	Tube	PL-6569	Penta
IV4	Tube	PL-6569	Penta

210A DRIVER HIGH VOLTAGE SUPPLY CHASSIS

C1 thru C96	Capacitor	0.1-mfd, 600-v, 111-6S1	Pyramid
C97 thru C100	Capacitor	10-mfd, 2.5-kv, 23F397	General Electric
CR1 thru CR96	Diode	IN 1695	General Electric
K1	Relay	CTI-617-XXA Curve 46	Heinemann
K2	Relay	CTI-617-XXA Curve 46	Heinemann

607 PREAMPLIFIER POWER SUPPLY CHASSIS

6C1 thru 6C3	Capacitor	2-mfd, 7.5-kv , 23F946-G103	General Electric
6C4	Capacitor	28-mfd, 1-kv, 21F426-G103	General Electric
6C5	Capacitor	28-mfd, 1-kv, 21F426-G103	General Electric
6K1	Relay	NC 6V 27DC-6-1C	Philtrol

CIRCUIT REF. NO.	DESCRIPTION OF PARTS		MANUFACTURER
6L1	Choke	10 HY at 150-ma , 3951	Wahlgren
6R1	Resistor	1K, 50W, 0405	Ohmite
6R2 thru 6R16	Resistor	470K, 1W	Ohmite
6R17	Resistor	100K, 25W	Ohmite
6R18	Resistor	1K, 2W, 50-ohms, M50PK	Mallory
6T1	Transformer, power	3844	Wahlgren
6T2	Transformer, filament	F-71U	Triad
6T3	Transformer, filament	F-71U	Triad
6T4	Transformer, filament	F-71U	Triad
6T5	Transformer, filament	PSR-150	Chicago
6V1 thru 6V4	Tube	966	United
6V5	Tube	5R4GY	R.C.A.

1102 ARM PROTECTION DUMP CHASSIS

11C1	Capacitor	.05-mfd, 12.5-kv, 28F71-G102	General Electric
11C2	Capacitor	100-mfd, 2.5-kv, HT-5310	Sangamo
11C3	Capacitor	14-mfd, 150-v, 102D154	Sprague
11C4	Capacitor	1000-mmfd, 2.5-kv, H-5210	Sangamo
11C5	Same as 11C4		
11C6	Capacitor	100-mmfd, 2.5.kv, HT-5310	Sangamo

CIRCUIT REF. NO.	DESCRIPTION OF PARTS		MANUFACTURER
11C7 thru 11C9	Capacitor	14-mfd, 150-v, 102D154	Sprague
11CR1 thru 11CR2	Rectifier, Sel	Bu-069	Fansteel
11R9 thru 11R10	Resistor	120K, 1W, 10 %	Ohmite
11R11	Resistor	15K, 2W, 10 %	Ohmite
11R12	Resistor	1.5K, 2W 1 %	Ohmite
11R13 thru 11R17	Resistor	390-ohms, 2W, 10%	Ohmite
11R18 thru 11R27	Resistor	1K-ohm, 5W, WW	Ohmite
11R28 thru 11R29	Resistor	10K, 2W, 10 %	Ohmite
11R31	Resistor	100-ohm, 50W, WW, 0400-F	Ohmite
11R32	Resistor	47K, 1W, 10 %	Ohmite
11R33	Resistor	100K, 2W, 10 %	Ohmite
11R34	Resistor	3.3K, 2W, 5 %	Ohmite
11R35	Resistor	100-ohm, 50W, WW, 0400-F	Ohmite
11R36	Rheostat	1-ohm, 100W, K-0441	Ohmite

CIRCUIT REF. NO.	DESCRIPTION OF PARTS		MANUFACTURER
11R37 thru 11R40	Resistor	12K, 2W, 10 %	Ohmite
11R41	Resistor	470K, 1W, 10 %	Ohmite
11R42	Resistor	5K, 25W, 0212	Ohmite
11R43 thru 11R44	Resistor	120K, 1W, 10 %	Ohmite
11T1	Transformer, filament	6SN7252	Thermador
11T2	Transformer, filament	6F5156	Thermador
11T4	Transformer	F-7X	Triad
11T5	Transformer, isolation	N-51X	Triad
11T6	Transformer, pulse	20595-1	Triad
11V1 thru 11V2	Tube	6279/5622	Amperex
11V3	Tube	OC3/VR105	R.C.A.
11V4 thru 11V6	Tube	5563A, LJ-24	R.C.A.
11V7	Tube	PC3/VR105	R.C.A.

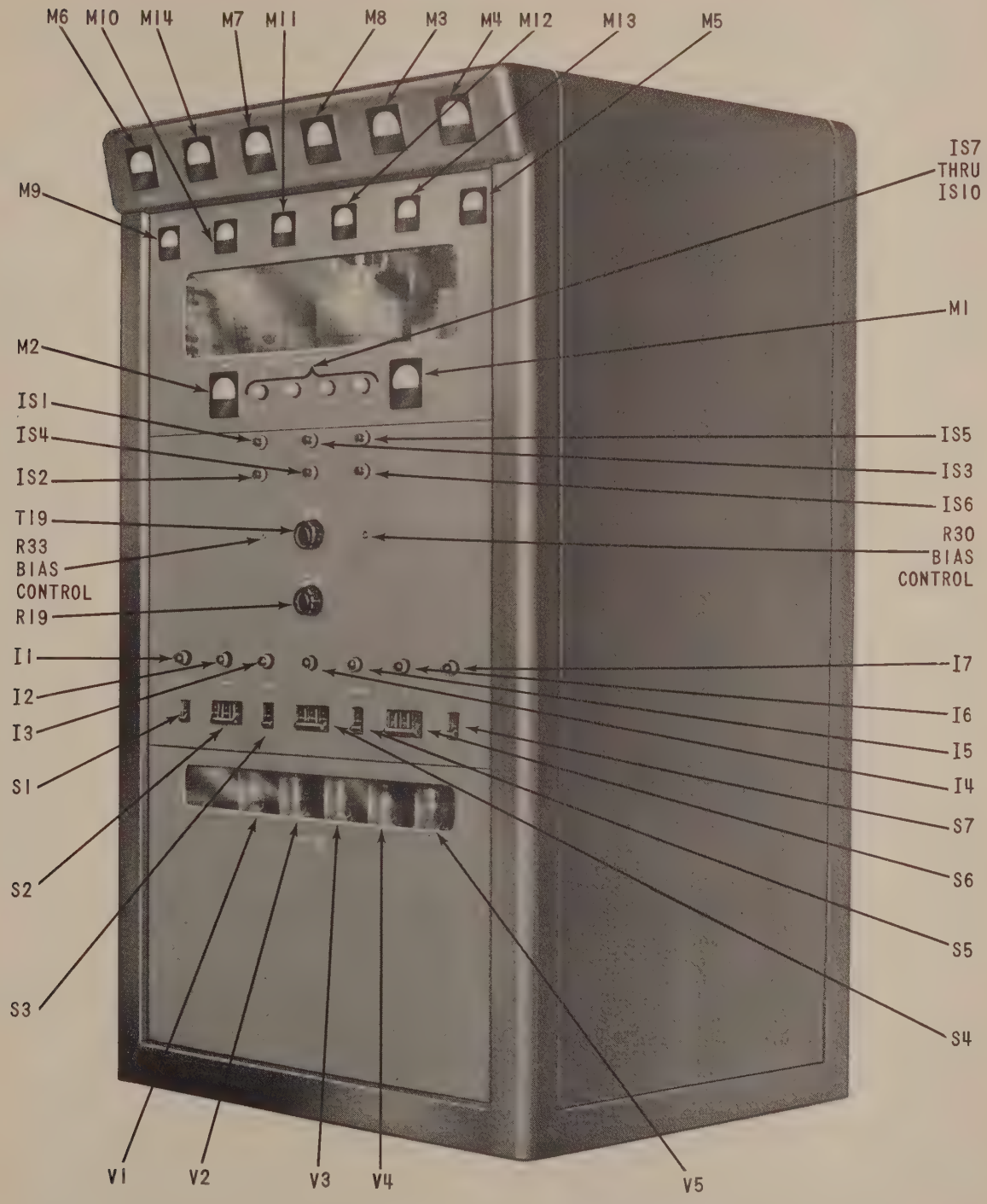


Figure 6-1. Model PP-20/24, Front View

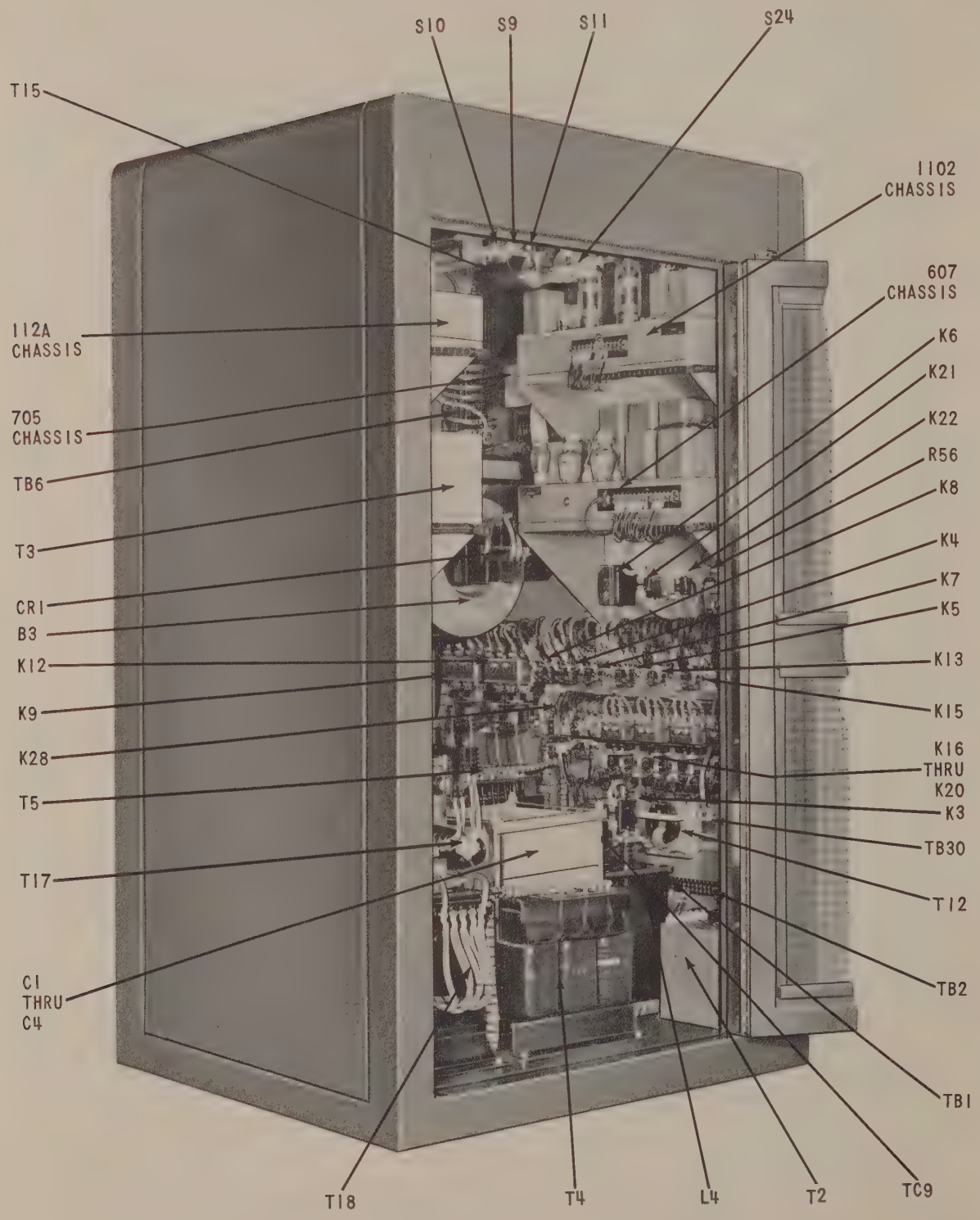


Figure 6-2. Model PP-20/24, Right Rear View

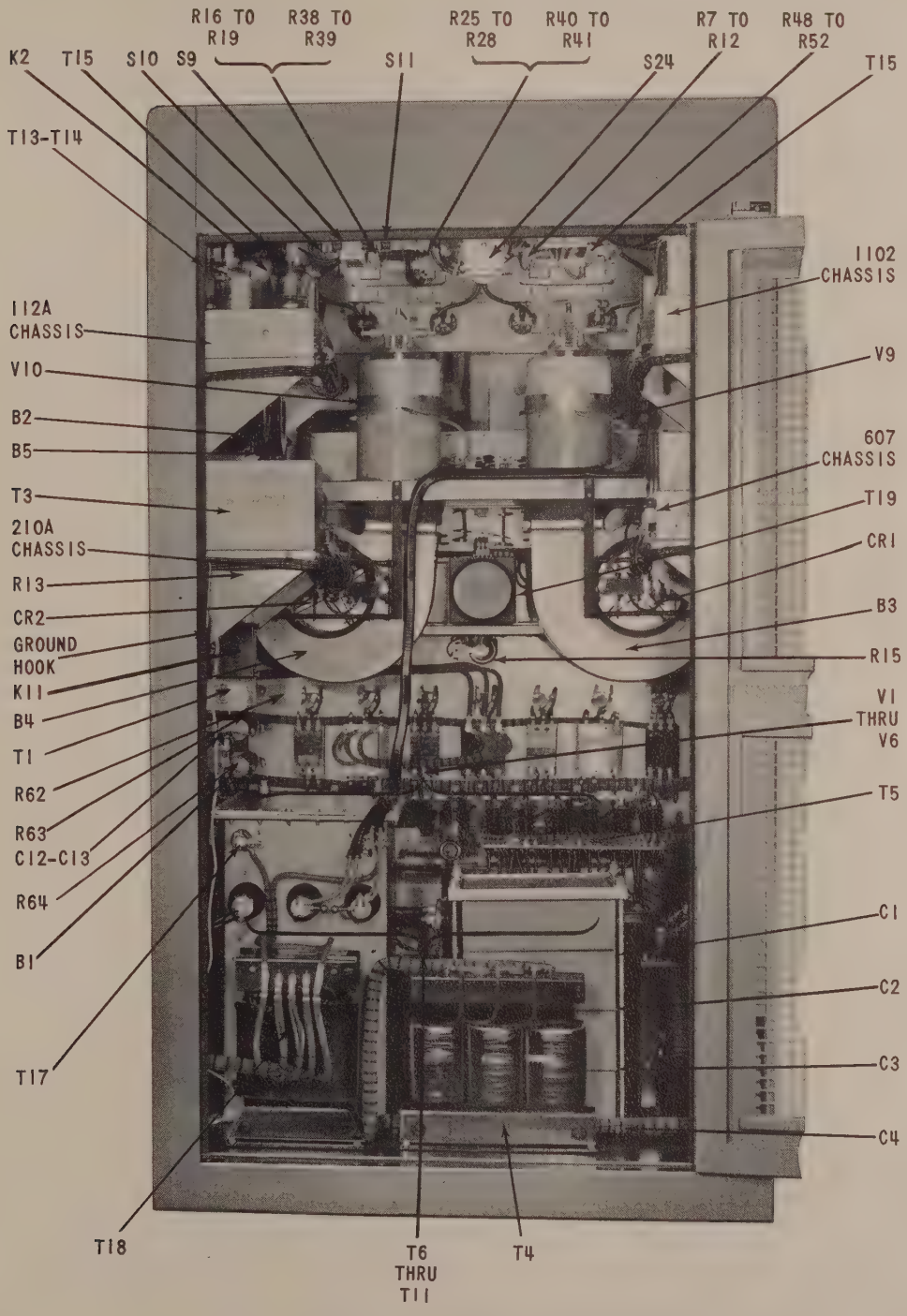


Figure 6-3. Model PP-20/24, Left Rear View

WARRANTY

Ling Electronics warrants each instrument manufactured by them to be free from defective materials and workmanship. Liability under this warranty is limited to service, adjustment, and replacement of any defective original equipment parts of the instrument. Liability under this warranty excludes electron tubes, which carry a standard EIA guarantee.

This warranty is effective for a period of one year from date of delivery to the purchaser. Any fault which has occurred through misuse, carelessness, abnormal conditions or modifications made to the instrument without consent of the manufacturer renders the warranty void and repairs will be billed at cost.

If any fault develops, the manufacturer should be notified giving full details of the trouble. The purchaser will be advised as to the disposition of the instrument and may request an estimate of any repair charges not covered by the warranty. Include model number and serial number of instrument in all correspondence with manufacturer.

CANCELLED
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THE LING ELECTRONICS TECHNICAL STAFF IS AT YOUR DISPOSAL.
PLEASE DO NOT HESITATE TO CALL US AT ANY TIME.

LING ELECTRONICS Division
LING-ALTEC ELECTRONICS, INC.
ANAHEIM, CALIFORNIA

LING ELECTRONICS

Division of Ling Altec Electronics

WARRANTY

LING ELECTRONICS Division (hereinafter referred to as Ling) warrants its products to be free of defects in materials and workmanship for a period of one year after shipment from its plant, or in the case of equipment requiring check out by an authorized representative of LING, warranty shall be one year from date of check out, but in any case, will expire 18 months from date of shipment. The offer for initial check out at no charge will expire 1 year from date of shipment. Check out will then be at prevailing service rates. This warranty does not cover the LING product unless it is properly installed and maintained in accordance with current instructions and manuals of LING, and unless it is used under normal operating conditions.

WARRANTY is limited to replacing or repairing any part or parts which have been returned to LING and which in our opinion are defective. Commercial parts purchased by LING and installed in the equipment will carry original Manufacturers Warranty only. In the case of defective components or products, LING reserves the right to request the prepaid return to the factory or to inspect them at the customer's installation and also reserves the sole right to determine whether defective components and products will be repaired or replaced.

WARRANTY does not cover any customer labor charges for replacement or parts, adjustments or repairs, or any other work, unless such charges be assumed or authorized in advance in writing by LING. LING service due solely to defects in material or workmanship will be supplied free of charge except that all transportation incurred during such service will be for the customer's account.

WARRANTY is expressly in lieu of any and all other warranties or representations, expressed or implied, and of any other obligations or liabilities of LING to the Buyer arising out of the use of the said product, and no agreement or understanding varying or extending the same will be binding upon LING unless in writing, signed by a duly authorized officer or representative.

WARRANTY shall not apply to any product, which in the judgment of LING, shall have been subject to misuse or neglect, or shall have been repaired or altered (after check out by an authorized representative of LING) outside the LING plant in any way which may have impaired its safety, operating or efficiency, nor to any product which has been subject to accident. Warranty shall not apply if any part not manufactured or supplied by LING for use in the operation thereof shall have been substituted and used in place of the part manufactured or supplied by LING for such use.

LING reserves the right to make changes in design or additions to or improvements in its products at any time without imposing any liability on itself to install the same in any product manufactured prior thereto. Equipment requiring check out by a LING engineer or serviceman should not be operated prior to this check out as the warranty on these specific products will be voided.

MEMORANDA

MEMORANDA

MEMORANDA

MEMORANDA

MODEL PS-1245

UNIT BASIC PARTS LIST SO _____ Date _____

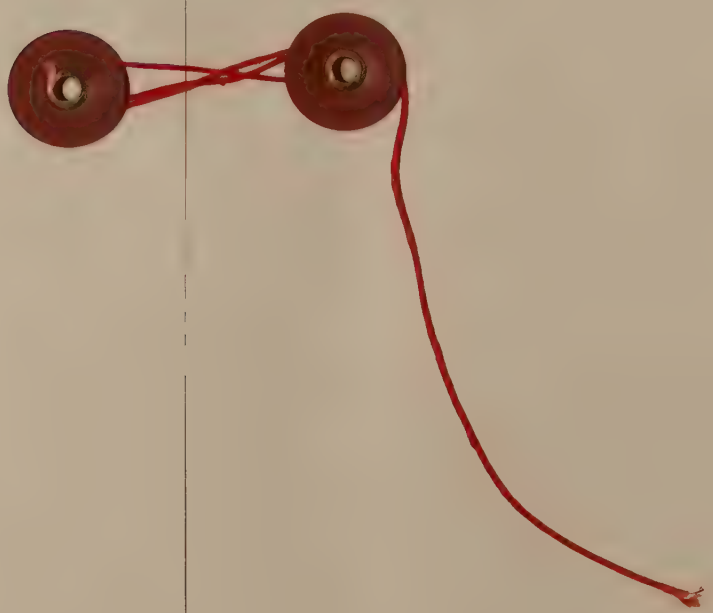
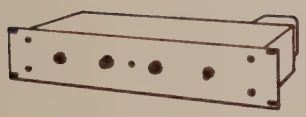
"L" PART NO.	PART NO. DWG. NO.	PART DESCRIPTION	QUAN PER UNIT	MANU-FACTURER	VENDOR	DATE ORDERED
	40809	Schematic to Rev. A				
		Transformer, Field 28 KVA CR 10271-A	1	PP		
		Rectifier Stack Standard Rectifier S-1015 CZ-15	1	PP		
		Switch, 3 Pole, 4 Pos 100 A Barklew T-143A	1	PP		
		Capacitor 50 µf 600 V GE 23F713	2	PP		
		Resistor 10 K 50 W O 9215	1	PP		
		Resistor 1 ohm 10 W O 1-3[illegible]-48-F	1	PP		
		Knob GR KNS-12	1	PP		
		Meter, Field (use w/ext shunt) WE RX-35 0 - 150 ADC, 50 MV (Alum Panel)	1	PP		
		Meter, Field WE RX-35 0 - 300 VDC (Alum Panel)	1	PP		
		Shunt WE 703931 150 ADC, 50 MV	1	PP		

MODEL		UNIT	QUAN PER UNIT	MANU-FACTURER	VENDOR	DATE ORDERED	D
"L" PART NO.	PART NO. DWG. NO.	PART DESCRIPTION					
Ada		Transformer CR -*#1027/1-A	1	PI			
	20121						

MODEL		UNIT	QUAN PER UNIT	MANU-FACTURER	VENDOR	DATE ORDERED	DE
"L" PART NO.	PART NO. / DWG. NO.	PART DESCRIPTION					

MODEL	UNIT						
"L" PART NO.	PART NO. / DWG. NO.	PART DESCRIPTION	QUAN PER UNIT	MANU-FACTURER	VENDOR	DATE ORDERED	ID

Field Supply Schematic
#40809



MODEL DA-10B
CONTROL SELECTOR

LING ELECTRONICS Division
LING-ALTEC ELECTRONICS, INC.
1515 So. Manchester Avenue
Anaheim, California

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SECTION 1

DESCRIPTION AND CHARACTERISTICS

1-1. GENERAL

The Ling Electronics Model DA-10B Control Selector (hereafter referred to simply as the DA-10) is a dual channel transfer unit designed to select for control purposes the higher of two input signals. Normally, the two input signals are proportional to displacement and acceleration of a shaker, and the DA-10 is used as part of a servo system, such as the Ling Model S-14.

1-2. PURPOSE

When used as a part of a servo system for vibration testing, the DA-10 selects the controlling signal to which the servo system must respond.

1-3. CHARACTERISTICS AND SPECIFICATIONS

All components of the DA-10 are contained in one rack-mounting chassis 12 inches deep, 19 inches wide, and with panel height 3 1/2 inches. The front panel contains indicator lights telling that the unit is on, and indicating whether the unit is switched to displacement or to acceleration, and a power switch. The balance control is also a screwdriver adjustment on the front panel. The DA-10 has its own self-contained power supply.

Specifications for the DA-10 Control Selector are as follows:

Power requirements	115 volts a-c, 60 cps, 50 va
Input signal (Two inputs)	0.7 volt rms, normally from Ling M-14A Vibration Meter or similar device.
Output signal	One or the other input, depending on which is the higher level.
Size	Panel, 3 1/2 inches x 19 inches Standard rack mounting Chassis, 12 inches deep x 17 inches wide.
Weight	12 pounds

1-4. TUBE COMPLEMENT

REFERENCE SYMBOL	TYPE	FUNCTION
V1	6AN8	Voltage amplifier, D channel
V2	6AN8	Voltage amplifier, G channel
V3	6H6	Diode, D channel
V4	6H6	Diode, G channel
V5	2050	Relay thyratron
V6	5Y3	Rectifier

SECTION 2
OPERATION

2-1. PREPARATION

Initial installation of all Ling vibration-testing systems is accomplished under the direction of expert field-service personnel supplied by Ling as a part of the equipment contract. When the DA-10 Control Selector is a part of a complete system, such as the S-14 Servo System, Ling personnel perform the necessary interconnections, such unpacking operations as may be required, initial checkout and test, and briefing type instruction for customer personnel.

The DA-10 is available as a separate equipment item, however, for other uses or for expansion of existing servo systems to multiple-level operation. In these cases, initial preparation consists of unpacking the unit, inspecting the components carefully for any evidence of shipping damage, mounting in a suitable rack, and wiring.

A terminal strip having a total of 10 connections is mounted on the rear of the DA-10 and all connections to and from the unit are made by way of this terminal strip. Connections to the terminal strip are as follows:

Terminal No.	Connection
1	Chassis ground
2	Circuit ground
3	115 v a-c, 60 cps, 50 va
4	115 v a-c, 60 cps, 50 va
5	Circuit ground
6	D input
7	G input
8	Output
9	To external circuit
10	To external circuit

2-2. OPERATION

The DA-10 is placed into operation by throwing the toggle switch S-1 to "ON". With S-1 "OFF", the selector is automatically bypassed, the output being connected to the G input. With S-1 "ON", the output will transfer to the D input in the event that the D signal exceeds the G signal. That is, the DA-10 responds to the larger of the two signals, D or G, and switches the output to whichever signal is the larger. In the usual servo application, as frequency changes from a low to a high value, at first the displacement remains constant and the acceleration increases to some maximum level; and thereafter, the acceleration remains constant and the displacement decreases. Thus the DA-10 switches at the crossover point, where the signals from each of the two channels are equal.

Screwdriver adjustment R27 is normally set at the factory to provide the correct switching level, at around 0.7 volt rms for each input, and seldom needs to be changed in operation. Indicator lights on the front panel tell whether the DA-10 is switching to the D or G position.

SECTION 3

PRINCIPLES OF OPERATION

3-1. INTRODUCTION

The Ling Model DA-10B Control Selector is a switching device to automatically select the larger of two input signals, as the controlling signal for a servo system as used in vibration-testing applications. The two input signals are normally proportional to displacement or acceleration, but may also be proportional to velocity, depending on the particular type of servo being used. Several DA-10 units may be used in multiple-level servo systems. The DA-10 consists of two identical voltage amplifiers, two diode rectifiers producing positive and negative signals proportional to the peak-to-peak value the input signal (positive on D channel and negative on G channel), and a thyratron-operated relay.

3-2. CIRCUIT DESCRIPTION

The complete schematic of the DA-10 (excluding shielded leads for simplicity) is shown in Fig. 3-1. Input signals enter the two channels from terminals 6 and 7 for D and G, respectively, and one or the other of these input signals is switched to the output, terminal 8, by the contact of relay K1. K1 is operated by thyratron V5 whenever the control-grid voltage of V5 becomes sufficiently positive to cause the tube to fire.

Each voltage amplifier is stabilized by negative feedback, both due to the use of unbypassed cathode and screen resistors in V1 and V2, and due to feedback resistors R9 and R18 in the D and G channels, respectively. The net over-all voltage gain of each amplifier is approximately 70. Output of each voltage amplifier is rectified by diodes, V3 for the D channel, and V4 for the G channel.

As may be seen from the diagram in Fig. 3-1, diode polarity is such that the polarity of voltage appearing across capacitors C7 and C8 for the D and G channels, is opposite, being positive for the D channel and negative for the G channel. In each case, the magnitude of the voltage is proportional to the peak-to-peak value of the input signal, since the two halves of each diode V3 and V4 act as a voltage doubler. In the case of the D channel, on the negative half cycle of the input signal, the signal at the plate of V1B is also swinging negative, and diode V3B conducts, charging series capacitor C3 to a polarity that is positive with respect to the plate of V3A. On the next half cycle, the signal at the plate of V1B adds to that voltage stored in C3, and diode V3A conducts, charging C7 positively with respect to circuit ground. In the G channel, the action is reversed and the voltage across C8 is negative with respect to ground.

The voltages across C7 and C8 are combined in a resistance mixer, so that their net difference appears as control-grid bias on thyratron V5. The shield grid of V5 is connected to a negative voltage obtained by placing a variable dropping resistor R27 in series with the center-tap of the power supply. The shield grid of the 2050 is adjusted so that conduction will occur with a grid voltage of zero volts plus or minus a very small differential. Thus the tube will fire whenever the positive signal, proportional to the D channel input signal, exceeds the negative signal, proportional to the G channel input signal, by the differential voltage. This differential is due to the characteristics of the relay and thyratron V5 and is on the order of plus or minus 0.25 volts or less at the grid of V5.

The gain of the amplifier reduces this to less than plus or minus 0.03 volts as seen at the D and G inputs.

The plate of V5 is returned to the secondary of power transformer T1, which produces an a-c voltage of approximately 425 volts rms with respect to the center tap. When the thyratron fires, relay K1 is caused to close. Current pulsations through K1 are filtered by capacitor C11. The thyratron conducts only on the positive half cycles of voltage across T1, and will continue to so conduct as long as the grid voltage is such as to cause the tube to fire. If the grid voltage decreases below the firing point, however, the tube will extinguish on the next half cycle of T1 voltage following the time at which the grid voltage decreases. The R-C filter in the grid circuit of V5 slows the response time to prevent chatter and tripping on spurious signals or spikes of short duration, or due to feedback from the transients caused by the inductance of relay coil K1.

A second set of contacts of K1 connect indicator lights IS2 and IS3 to the filament supply through a series dropping resistor to reduce their brilliancy. These indicators then display the position in which K1 appears.

As bias resistor R27 is turned clockwise, more resistance is placed into the circuit, so the shield grid of V5 is made more negative. Normally, the setting of R27 is determined as a factory adjustment which should not require readjustment in the field. Normal setting is for inputs of 0.7 volt rms on each of the two channels.

3-3. DA-10C MODIFICATION

Although in the majority of applications, the DA-10B selects the larger of two input signals in the manner described, there are one or two cases where it is necessary for the DA-10 to select the smaller of two input signals.One such application is in the four-level S-14 Servo System. This modified unit is called the DA-10C, and the modification consists simply of reconnecting the relay contacts for both the selection circuit and indicator lights so that the channel switching is opposite to that for the DA-10B.The connection changes are noted in Fig. 3-1 by showing the relaxed (de-energized) position of the relay as being the D position rather than the G position, in dotted form. The remainder of the circuit is the same, and operation is as described herein.

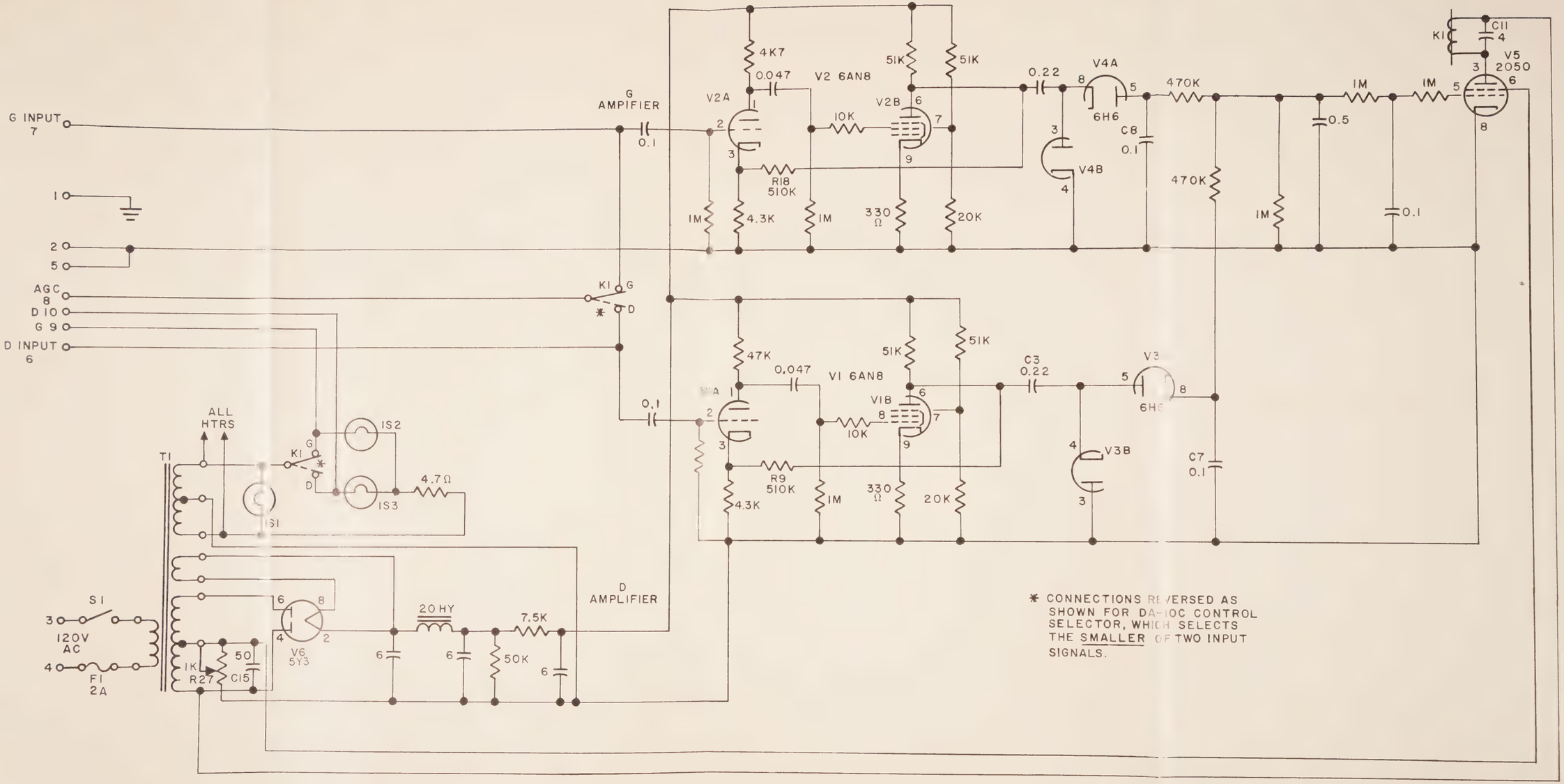


Figure 3-1 Model DA-10B Control Selector, Simplified Schematic

SECTION 4

MAINTENANCE

4-1. ANALYSIS

Before attempting maintenance or repair of the DA-10B Control Selector, make certain that the device is actually at fault. In its usual application, one or more DA-10 units are used within a servo system, which in turn is part of a complete vibration-testing system consisting of signal source, signal conditioners (equalizers, filters, etc.), power amplifier, shaker, and instrumentation. The trouble should be carefully and methodically localized by making a series of logical and orderly tests before assuming the DA-10 to be at fault. The trouble may lie elsewhere in the system.

The DA-10 is conservatively designed and carefully constructed, insuring long component life with trouble-free operation. It is probable that tube replacement will correct most of the difficulties that may be encountered in operation of the unit.

Before attempting maintenance of the DA-10, become thoroughly familiar with the principles of operation of the unit as described in Section 3 of this operation and maintenance manual.

4-2. TROUBLESHOOTING

The following are suggested causes and/or remedies for troubles that might occur in the DA-10:

TROUBLE	REMEDY AND/OR CAUSE
Unit does not come on with power switch	Check for blown fuse F1 Check further for cause of fuse blowing; possible shorted rectifier V6, shorted relay capacitor C11, shorted filter capacitors in power supply.
Indicator lights do not light	Check lamp bulbs in indicators.
No transfer, or transfer erratic	Check for heater-cathode shorts in diodes V3 and V4 Check for open grid resistor at V5 Check amplifiers V1 and V2 Check power supply Check for open adjustment R27 Check for shorted capacitor C15 Check for open relay coil on K1 Check for excessive leakage in C7 or C8 Check defective V5

4-3. OTHER DIFFICULTIES

In the event of troubles or problems not covered by this manual, contact the factory, giving the serial number of the unit, conditions of use, and full description of problem. Ling field-service personnel are constantly available for consultation on special problems, concerning utilization or application of Ling equipment, and upon making the necessary arrangements, can be on the scene within 24 hours.

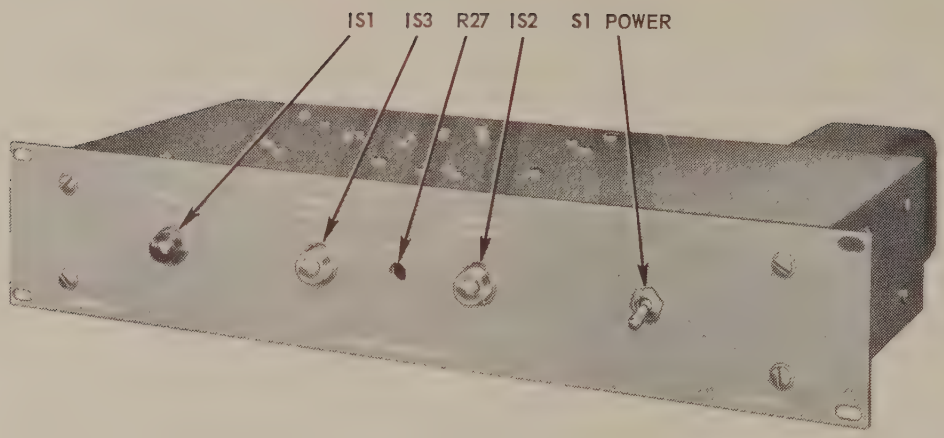


Figure 4-1 Model DA-10B Control Selector, Front View

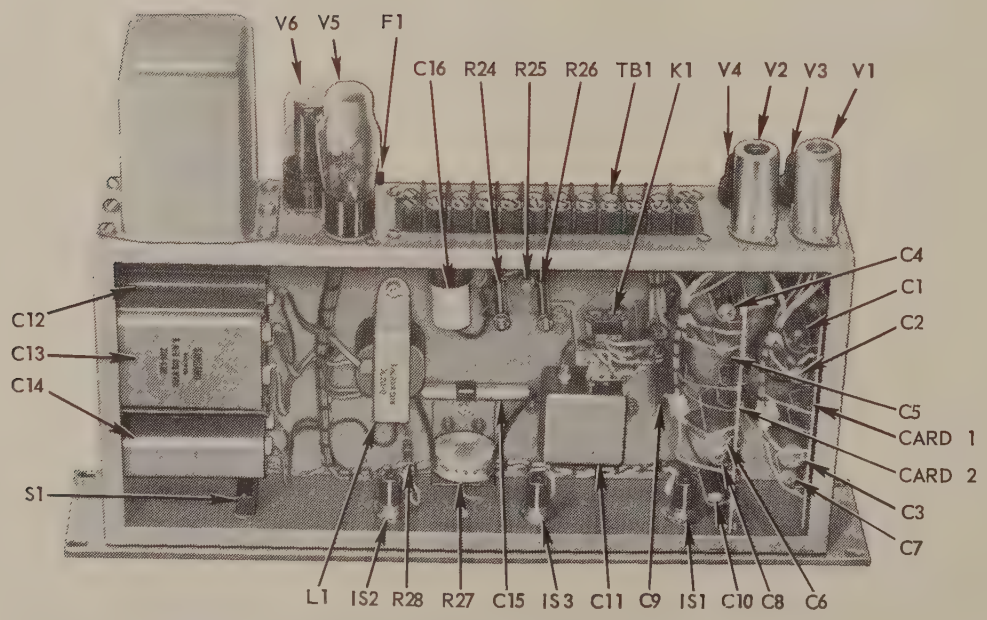


Figure 4-2 Model DA-10B Control Selector, Bottom View

SECTION 5
REPLACEABLE PARTS LIST

REPLACEABLE PARTS LIST

DA-10-B CONTROL SELECTOR SERIAL NO. 329

SCHEMATIC DESIG.	DESCRIPTION					MANUFACTURER (SEE CODE) AND MANUFACTURER'S PART NO.
C1	Capacitor	Mylar Paper	0.1 mfd	400V		PY - 111-4P1
C2	Capacitor	Mylar Paper	0.047 mfd	600V		PY - 111-6S47
C3	Capacitor	Mylar Paper	0.22 mfd	600V		PY - 111-6P22
C4	Capacitor	Mylar Paper	0.1 mfd	400V		PY - 111-4P1
C5	Capacitor	Mylar Paper	0.047 mfd	600V		PY - 111-6S47
C6	Capacitor	Mylar Paper	0.22 mfd	600V		PY - 111-6P22
C7	Capacitor	Mylar Paper	0.1 mfd	400V	5%	PY - 111-4P1 - 5%
C8	Capacitor	Mylar Paper	0.1 mfd	400V	5%	PY - 111-4P1 - 5%
C9	Capacitor	Metalized Paper	0.5 mfd	400V		AR - P123ZGP
C10	Capacitor	Metalized Paper	0.1 mfd	400V		AR - P123ZGP
C11	Capacitor	Metalized Paper	4 mfd	600V		AR - P30Z
C12	Capacitor	Pyranol	6 mfd	600V		GE - 23F352-G102
C13	Capacitor	Pyranol	6 mfd	600V		GE - 23F352-G102
C14	Capacitor	Pyranol	6 mfd	600 VDC		GE - 23F352-G102
C15	Capacitor	Electrolytic	50 mfd	50V		SP - 102D135
C16	Capacitor	Paper	0.1 mfd	600V		PY - 111-6P1
P1	Fuse		2A	250V	3 AG	LI
IS1	Indicator (Red)		6V (with T47 lamp)			DI - 91410-931
IS2	Indicator (Amber)		6V w/T47 lamp			DI - 91510-933
IS3	Indicator (Amber)		6V w/T47 lamp			DI - 81410-933
K1	Identify as ordered					Philtrol - 8DC-115-4C Code 24 Contact
L1	Choke		20 Hy	30 MA		TH - 712030
R1	Resistor	Composition	1M	1/2W	10%	AB
R2	Resistor	Composition	47K	1W	10%	AB
R3	Resistor	Composition	4.3K	1W	5%	AB
R4	Resistor	Composition	1M	1/2W	10%	AB
R5	Resistor	Composition	51K	1W	5%	AB
R6	Resistor	Composition	330 ohm	1/2W	10%	AB
R7	Resistor	Composition	51K	1W	5%	AB
R8	Resistor	Composition	20K	1W	5%	AB
R9	Resistor	Composition	510K	1/2W	5%	AB
R10	Resistor	Composition	1M	1/2W	10%	AB
R11	Resistor	Composition	47K	1W	10%	AB
R12	Resistor	Composition	4.3K	1W	5%	AB
R13	Resistor	Composition	1M	1/2W	10%	AB
R14	Resistor	Composition	51K	1W	5%	AB
R15	Resistor	Composition	330 ohm	1/2W	10%	AB
R16	Resistor	Composition	51K	1W	5%	AB
R17	Resistor	Composition	20K	1W	5%	AB
R18	Resistor	Composition	510K	1/2W	5%	AB
R19	Resistor	Deposited Carbon	470K	1/2W	1%	WEL - C12-470K
R20	Resistor	Deposited Carbon	470K	1/2W	1%	WEL - C12-470K
R21	Resistor	Composition	1M	1/2W	10%	AB
R22	Resistor	Composition	1M	1/2W	10%	AB
R23	Resistor	Composition	1M	1/2W	10%	AB
R24	Resistor	Wire-Wound	10K	10W		0

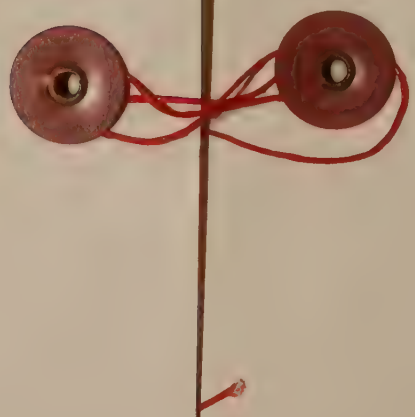
DA-10-B CONTROL SELECTOR SERIAL NO. 329

SCHEMATIC DESIG.	DESCRIPTION					MANUFACTURER (SEE CODE) AND MANUFACTURER'S PART NO.	
R25	Resistor	Wire-Wound	50K	10W		O	
R26	Resistor	Wire-Wound	7.5K	10W		O	
R27	Potentiometer	Wire-Wound	1000 ohm	4W		MA - M1MPK	
R28	Resistor	Composition	4.7 ohm	1W	10%	AB	
R29	Resistor	Composition	10K	1W	10%	AB	
R30	Resistor	Composition	10K	1W	10%	AB	
S1	Switch	Toggle	DPST			ARROW HART 8099A-BD	
T1	Transformer	Power				CH - PRS-70	
	Insert	Tube Shield	Heat Dissipating			BIRT - 75614-2	ELCO - 933
V1	Tube		6AN8			RCA	
V2	Tube		6AN8			RCA	
V3	Tube		6H6			RCA	
V4	Tube		6H6			RCA	
V5	Tube		2050			RCA	
V6	Tube		5Y3			RCA	
X1	Socket	Tube	Noval with shield			ELCO - TS103-P01	
X2	Socket	Tube	Noval with shield			ELCO - TS103-P01	
X3	Socket	Tube	Octal			AMP - 77MIP-8T	
X4	Socket	Tube	Octal			AMP - 77MIP-8T	
X5	Socket	Tube	Octal			AMP - 77MIP-8T	
X6	Socket	Tube	Octal			AMP - 77MIP-8T	

CODE TO MANUFACTURERS

AA	AIR ASSOCIATES
AB	ALLEN BRADLEY
AC	ASTRON CORPORATION
AD	ADVANCE RELAY
ADEL	ADEL
AI	AIRCRAFT
ALB	ALBION
ALL	ALLIS CHAMBERS
AME	AMPERITE CO.
AMP	AMPHENOL
APH	ALPHA
AQ	AEROQUIP
AR	AEROVOX
ARCO	ARCO ELECTRONICS
ARM	ARMSTRONG CORK CO.
ASP	ASSEMBLY PRODUCTS
BAS	BASSICK
BC	BARBAR COLMAN
BECK	BECKMAN INSTRUMENTS
BEL	BELDEN
BG	BOSTON GEAR
BI	BIRNBACH
BIRT	BIRTCHER
BO	BODINE
BOU	BOURNS "TRIMPOT"
BOW	BOWERS
BRE	BREEZE "AERO SEAL"
BRY	BRAYANT
BUD	BUD
BUG	BUGGIE
BUR	BURROUGHS
BUSS	BUSSMAN MFG.
C	CHATHAM
CA	CARLING ELECTRIC
CALC	CALIFORNIA CHASSIS
CAN	CANNON
CCI	CONTINENTAL CARBON, INC.
CD	CORNELL DUBILIER
CH	CHICAGO STANDARD TRANS.
CHD	CROUSE HINDS
CHSH	CHASE-SHAWMUT
CI	CINEMA
CJ	CINCH-JONES
CK	CONROY & KNOWLTON
CL	CLARK CONTROLER CO.
CP	COMMUNICATION PROD.
CRA	CRAMER
CRAF	CRAFTSMAN
CRIT	CRITTENDEN
CRL	CENTRALAB
CRN	CRANE
CU	CURTIS
CUT	CUTLER HAMMER
D & H	D & H AWNING
DA	DAYTON
DI	DIALITE CORP. (DIALCO)
DICO	DIAMOND MFG. (DICO)
DM	DIAMOND METAL
DRAK	DRAKE - ATWOOD
DUC	DUCOMMON
DUM	DUMONT
DY	DYNAC
ED	EDCLIFF INST.
EEW	ELECTRO ENG. WORKS
EF	ELECTRO FAB.
EI	EIMAC
EM	ELECTRO-MEASUREMENTS
EMC	EMCOR
EMEC	EMEC
EMP	EMPCO
EP	ENGINEERING PROD.
ER	ERIE
ES	EAGLE SIGNAL
ESX	ESSEX
F	FENWAL
FAN	FANSTEEL
FED	FEDERATED
FEI	FEDERAL ENTERPRISE, INC
FF	FEDERAL FASTENING
FR	FRANZ
FU	FULLER
ITT	FEDERAL (IT & T)
G	GRAYBAR
GA	GATES
GCON	GENERAL CONTROL
GE	GENERAL ELECTRIC
GLA	GEELAR
GL	GLOBAR
GR	GENERAL RADIO
GU	GUDEMAN
GV	G. V. CONTROL
HAW	HARTWELL
HAYS	HAYS MFG.
HE	HEINEMANN
HEW	HEWLETT PACKARD
HGR.	H. G. REISING
HL	HELIPOT
HOF	HOFFMAN
HP	HOPKINS
HS	HARDWARE SPEC.
HU	HUBBEL
HY	HYCOR
HYD	HAYDON
IL	ILSCO
ILG	ILG
INSU	INSULINE
IRC	INT. RESISTANCE CORP.
IREC	INT. RECTIFIER CORP.
IS	INSULATION SUPPLY
ITE	ITE CIRCUIT BREAKER
J	JOHNSON
JAN	JAN HARDWARE MFG.
JE	JEFFERSON
JEN	JENSEN
K	KIERLUFF
KU	KULKA
KZ	KURZ-KASCH
LA	LYNCH ASBESTOS
LAR	L. A. RESISTOR
LE	LEACH
LER	LERCO
LI	LITTLE FUSE
LING	LING ELECTRONICS DIV.
LMB	LMB
LP	LAPP
LPD	LA-DEAU PROD.
M	MILLEN
MA	MALLORY
MD	MICRODOT
ME	METTSCRAFT
MICA	MICAMOLD
MIN	MINARIK
ML	MACHLETT
MLR.	MILLER CO.
MMN	MARMON
MN	MARION
MON	MONITOR
MOS	MOSSMAN
MP	MAPLE PRECISION
MRC	MARCO
MRY	MURRAY
MS	MICROSWITCH
N	NATIONAL CO.
NC	NATIONAL WIRE & CABLE
NE	NETWORK MFG.
NEI	NATIONAL ELECTRONICS INC.
NEP	NATIONAL ELECTRICAL PROD.
NHBB	NEW HAMPSHIRE BALL BEARING
NIBC	NORTHERN INDIANA BRASS
NL	NATIONAL LOCK
O	OHMITE
OZ	O. Z. ELECTRICAL MFG CO.
PE	PEERLESS
PENN	PENN CONTROL
PH	PHILLIPS CONTROL (PHILTROL)
PREM.	PREMIER METAL PROD.
PRYN	PRYNE
PTB	POTTER - BRUMFIELD
PY	PYRAMID
QE	QUALITY ELECTRIC
R	ROTON
RAY	RAYTHEON
RBC	RUBBERCRAFT
RCA	RADIO CORP. OF AMER.
RCC	RADIO CONDENSER CO.
RDL	RADIO DEVELOPMENT LAB
RE	REPUBLIC GLASS
REN	RENBRANDT
ROB	ROBERTSHAW-FULTON CON.
ROME	ROME
RT	RATIGAN
S	SIMPSON
SA	SANGAMO
SAR	SARAN
SE	SERVICE
SEP	STANDARD ELECT.PROD.
SH	SHALL CROSS
SI	SIGMA
SIE	SOUTHWESTERN IND.ENG.
SKT	SARKES TARZIAN
SM	STANLEY MORRIS
SMC	SPECIALTIES MFG.
SMI	SMITH HERMAN
SOLA	SOLA ELECTRIC
SP	SPRAGUE
SPR	SUPREME
SQ	SQUARE D
SR	SIERRA ELECT. CORP.
ST	STAGNARO
STAH	STAHLIN BROS.
STW	STANDARD WIRE & CABLE
SU	SUPERIOR ELECTRIC
SW	SWITCHCRAFT
SY	SYLVANIA
T	TRIAD
T & B	T & B (CONNECTORS)
TH	THERMADOR
TI	TEXAS INSTRUMENT
TIC	TECHNOLOGY INST.CORP.
TNG	TUNGSOL
TR	TRUMBEL
TRE	TRERICE
TRIM	TRIMM
TW	TRADEWIND
TX	TEKTRONIX
UI	UNISTRUT
UN	UNIMAX
USDG	U. S. ELECT. DEVEL.
USEC	U. S. ENG. CO.
USG	U. S. GAUGE
UTAH	UTAH
UTC	UNITED TRANSFORMER
WA	WALSCO
WAT	WATERS
WB	WARNER BRAKE
WC	WEST COAST (WESCO)
WE	WESTINGHOUSE
WEL	WELWYN
WES	WESTON
WH	WAHLGREN
WHD	WEATHERHEAD
WK	WECKESSER
WL	WARD LEONARD
WP	WESTCAP
WRNE	WESTERN ELECTRIC
WYCO	WYCO METAL PROD.
Y	YERKOVITCH - SIMON
YO	YOUNG RADIATOR

Console R-1003 Schematics
#41107 and 41106



PRODUCTION CHANGE SHEET

for

Models CO-10-A and CO-10-B

CYCLING OSCILLATORS

Date	Serial	Affects	Item	Change
11/30/59	635 & up	Schematic & Parts List	R76	Value to 5.6K 1W, 5%, Dymec stk. no. to 1068-5625, Mfr. stk.no. to B, GB5625.

HANDBOOK

for

Models CO-10-A and CO-10-B

CYCLING OSCILLATORS
Serials 635 & above

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LING-ELECTRONICS DIVISION
LING-ALTEC ELECTRONICS, INC.
1515 West Manchester
Anaheim, California

Pub. 10/59

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SECTION 1
GENERAL DESCRIPTION

1.1 DESCRIPTION

The CO-10-A and CO-10-B Cycling Oscillators are general-purpose swept-frequency oscillators which produce a continuously-adjustable output signal from 5 to 5000 cycles per second in the A model (10 to 10,000 cps in the B model) in one band at output levels from .01 to 1 volt open circuit with less than 1% distortion and ±1 db amplitude variation over the band. The output frequency is read from a hand-calibrated, six-inch-diameter dial having essentially logarithmic calibrations over 300° of arc. The output frequency can be swept repetitively over all, or any selected portion, of the full frequency band at any rate continuously-adjustable from 2.3 to 600 degrees per minute, cw and ccw sweep rates being equal. Selection of the desired sweep band and rate of sweep are both very simply selected on front-panel controls. The frequency dial calibration is accurate to within ±6% under all conditions of operation (initially calibrated to 1% at specified line voltage and 25°C ambient temperature). The rate dials are accurate to within ±5% at the end points of the vernier knob; intermediate vernier calibrations are nominal. The sweep mechanism in no way inhibits manual frequency selection.

An output sweep voltage is produced concurrently with the frequency sweep for sweeping graphic recorders and oscilloscopes presenting a display of output amplitude vs frequency, with the frequency presented on a true logarithmic base.

The output level is continuously adjustable from .01 to 1 volt rms or better by a front-panel control arbitrarily calibrated from 0 to 10. The output has a source impedance of 100 ohms and can be used either grounded or ungrounded. A front-panel meter continuously monitors the output level in volts to an accuracy of ±5% of full scale.

The oscillator features simplicity of operation, direct-reading controls, high waveform purity and stability and flat frequency response over the entire range, both with

single and swept frequencies. No zero setting is required. Provision is made for self checking the oscillator frequency against the line frequency. The oscillator is designed and constructed to give a high level of performance, and a long trouble-free life. Each instrument is thoroughly tested at the factory before shipping and is ready for use as received.

The oscillators in the CO-10-A and B are manufactured by Dymec, a division of the Hewlett-Packard Company, Palo Alto, California.

1.2 SPECIFICATIONS

FREQUENCY RANGE:	CO-10-A: 5 to 5000 cps, in one band. CO-10-B: 10 to 10,000 cps.
FREQUENCY SWEEP	
RATE:	Continuously adjustable from 2.3 to 600°/minute.
RANGE:	Continuously adjustable from any 7° to 320° of frequency dial rotation.
FREQUENCY DIAL:	Six-inch-diameter dial calibrated over 300° of arc; accurate to within ±6% at normal operating temperatures (includes initial warm-up and changes due to aging of components) dial hand-calibrated to ±1%.
FREQUENCY RESPONSE:	±1 db over full frequency range.
OUTPUT:	Continuously adjustable from .01 to 1 volt into open circuit. Meter indication accurate to within ±5%.
DISTORTION:	Less than 1% total harmonic distortion.
NOISE:	Less than 0.1% of rated output. Decreases as output is attenuated.
POWER:	115/230 v ±10%, less than 100 W.
DIMENSIONS & WEIGHT:	Rack mount: 18-15/16" wide, 7" high, 16 5/16" deep; 35 lbs.

SECTION 2
OPERATING INSTRUCTIONS

2.1 INSTALLATION

The CO-10-A is constructed for mounting in a standard 19-inch-wide relay rack, secured by four machine screws through the front panel. When mounting, do not obstruct the ventilating holes in the top and bottom plates. The frequency dial is calibrated, and is most accurate, at normal room temperature. If the CO-10-A is to be mounted in an enclosed cabinet with other heat-producing instruments, for best frequency calibration accuracy, the cabinet should be ventilated to prevent high ambient temperatures from developing. There are no other installation precautions.

2.2 POWER LINE CONNECTION

The power cord for the CO-10-A is terminated in a three-contact plug, consisting of a round pin added to a standard two-blade a-c plug. The round pin is connected to the instrument chassis and grounds the instrument when used in a mating receptacle. To use in a standard a-c receptacle, use an adapter. The chassis grounding wire is terminated in the adapter by a pigtail lead which can be attached to the standard a-c outlet mounting box to ground the instrument chassis.

The primary connections to the power transformer are normally connected for 115-volt operation and are wired to simplify conversion from 115-volt to 230-volt operation. To connect the transformer for 230-volt operation, refer to para. 4.3.

2.3 CONTROLS AND TERMINALS

POWER	SPST toggle switch. In the on position, it applies line voltage to the power supply transformer. With the transformer energized

supplying power to all sections except the driver motor, an indicator lamp lights and is visible through the frequency dial index window.

FREQUENCY DIAL

Varies the setting of the variable capacitor in the frequency-controlling section of the oscillator circuit. The setting of the frequency dial is the frequency of the output voltage.

The tuning capacitor gives a logarithmic increase in output frequency as the frequency dial is turned counterclockwise. Frequency dial calibration is accurately logarithmic down to approximately 50 cycles, below which it departs from a true logarithmic curve. This departure is relatively unimportant for many applications; however, when using an oscilloscope or graphic recorder to display frequency response, this departure can be readily compensated for by using the output sweep-voltage so that no significant error is obtained on the display.

Mounted coaxially on the frequency dial are the protractor and frequency range limit stop dials and control knob. The first of these dials is marked "rotation in degrees" and is calibrated from 0 to 320° in increments of 2 degrees. At the 0 position is an indexing pin which is the low frequency range limit stop. The second dial is smaller, without markings, and has an indexing pin

which is the high frequency limit stop. The black knurled skirt of the control knob when turned counterclockwise allows the limit stop dials to be positioned at the desired setting on frequency dial. Turning knurled skirt clockwise tightens limit stop dials.

The frequency dial is driven by means of a friction drive wheel on the rim of the dial. When the small coaxial knob is turned counterclockwise and loosened, the larger knob becomes an 8 to 1 vernier for manually tuning the frequency dial. Tightening the small knob in a clockwise direction engages a clutch and allows automatic operation.

OUTPUT (continuously-adjustable control)

Varies the setting of the attenuator in the output circuit; maximum attenuation with less than 0.1v output at the full ccw position and minimum attenuation with maximum output at the full cw position. The numerical designations which mark the range of the control from 0 to 10 are arbitrary units meant only as an aid to resetability of the instrument. The output (0-10v rms) is metered above this control.

CALIBRATE (SPST pushbutton)

When depressed, applies line frequency to the calibration circuit-bridge. The difference between the line frequency and the same frequency on the frequency dial appears on the output meter as a "beat" or fluctuation of the pointer enabling the operator to "zero in" the instrument by slipping the frequency dial until the pointer fluctuations cease.

MOTOR (SPST toggle switch)	In the on position, applies line voltage to the drive motor for automatic cycling of the oscillator. For manual operation this switch must be in the off position.
SWEEP RATE	Varies the sweep speed of the frequency dial in eight steps, each succeeding step being one-half the speed of the former step. This is accomplished by means of an eight-step planetary gear which is manually disengaged by pulling the large skirted knob (marked "PULL AND TURN") away from the panel and moving to any of the eight desired positions where a return spring will re-engage the planetary gear to the drive motor through jaw clutches. It is not necessary to stop the drive motor during sweep rate change nor is it necessary to stop at each succeeding step. Change may be made from one position to any of the other seven by moving pointer knob in either direction. The numerical designations which mark the eight positions of the control are approximate sweep rates in degrees of arc per minute corresponding to the planetary gear output to input shaft ratio of 1:1 to 128:1 in eight steps.
SWEEP RATE VERNIER	Varies the sweep speed of the frequency dial between steps of the main sweep rate control in a continuous manner up to double the sweep rate. This is accomplished by a rheostat and

capacitor in series with one stator winding of the drive motor which causes a change in voltage and phase relationship between the two stator windings. The numerical designations which mark the range of the control are approximate multipliers from 1.0 times to 2.0 times the sweep rate. The product of the sweep rate vernier setting times the main sweep rate control setting being the actual sweep rate or speed of the frequency dial in degrees of arc per minute.

NOTE: The front-panel calibrations for the SWEEP RATE VERNIER control are accurately set at the end points. Intermediate calibration points are approximate.

FUSE

Contains a slo-blo type cartridge fuse having a 1.6 ampere rating (for 115 volt line).

SWEEP VOLTAGE OUTPUT

The output of the sweep voltage potentiometer appears at two red binding posts on the rear of the instrument. The black post is connected to the chassis. Output may be made to recorder, X-Y plotter or horizontal input of an oscilloscope.

OUTPUT (terminals)

The output signal from the CO-10-A is obtained from the two red binding posts on rear of the instrument, and can be obtained either balanced or single-ended at 100-ohms internal impedance at maximum output. At lower output amplitudes the bridged-T output attenuator becomes unbalanced, but maintains a nominal 100-ohm output impedance.

To obtain a balanced output at levels below maximum output, either use a balanced line transformer between the CO-10-A output and the load, or set the control to maximum output and use a balanced attenuator between the output and the load. To use single-ended, connect the black, ground (left-hand) terminal to the center terminal. NOTE: The output meter is connected to a point in the circuit before the output terminals, consequently a "short" across the output terminals causes only a small decrease in the meter reading.

2.4 OPERATING PROCEDURE

With the instrument plugged into a power source of specified voltage and frequency, turn the power switch to on and allow the instrument to warm up for at least ten minutes. For maximum accuracy, the warmup period should be extended to one hour.

Set the output control at the zero position and make the necessary connections to the sweep voltage output plug and oscillator voltage output binding posts. The CO-10-A may be considered a 1-volt generator with an internal impedance of 100 ohms and may be connected to any load without affecting purity of waveform.

2.4.1 Manual Operation:

(1) For manual operation, disengage clutch by loosening (turn ccw) the small coaxial knob at the rim of the frequency dial. Set dial for the desired frequency of output voltage and adjust amplitude control for the desired level of output voltage as indicated on the meter.

2.4.2 Automatic Operation:

(1) For automatic operation, engage clutch by tightening (turn cw) the small coaxial knob at the rim of the

frequency dial. Loosen (turn ccw) the black knurled skirt of the frequency-dial control knob and set the indexing pins on the frequency-range-limit stop dials at the high and low-frequency limits of the desired sweep range. Tighten (turn cw) the black knurled skirt of the control knob.

(2) With the aid of the sweep-rate nomogram (Figure 2.1), determine the setting of the main sweep-rate control and vernier sweep rate control. The correct settings are found by placing the nomogram ruler on the T scale at the desired time in minutes for one sweep and intersecting the D scale at the dial displacement in degrees between the frequency limits. Read the main and vernier control settings where the nomogram ruler intersects the V and M scales. The sweep rate vernier control may have to be re-adjusted during the operation to compensate for warm up, component aging, line voltage fluctuations, etc.

(3) With the instrument set up as prescribed, turn the motor switch to on and adjust the output control to the desired level of output voltage as indicated on meter.

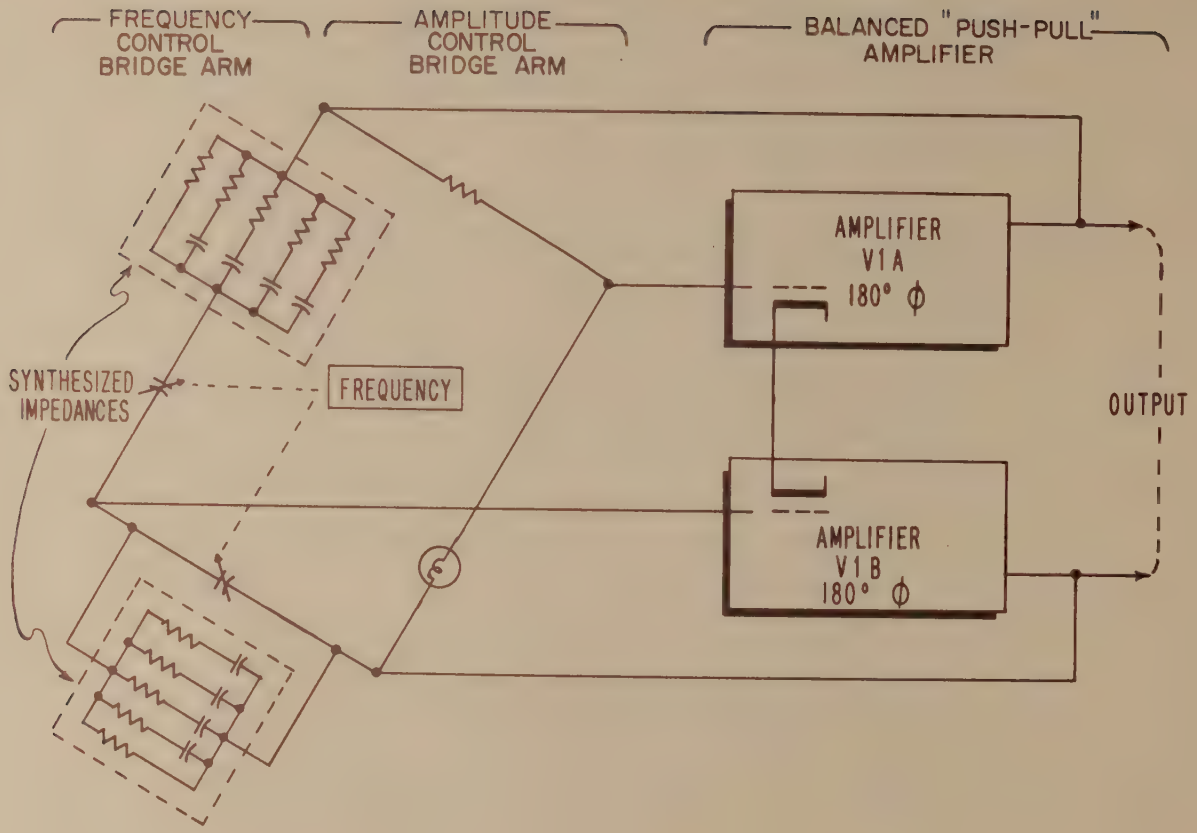


Figure 3-1 Functional Block Diagram of the CO-10-A and CO-10-B Cycling Oscillators

SECTION 3
THEORY OF OPERATION

3.1 OVERALL OPERATION

The CO-10-A Cycling Oscillator uses a Hewlett-Packard impedance-capacitance-tuned oscillator with a four-stage, balanced (push-pull) amplifier feeding the external load directly, without the need for a buffer amplifier. The balanced cathode-follower output stage is coupled through an output transformer, bridged-T attenuator and resistive divider to the output terminals. The block diagram in Figure 3-1 shows the circuits of the oscillator.

The two sides of the balanced amplifier are identical, independent up to the output transformer, symmetrical about 0 volts (ground), operate 180° out of phase with each other and introduce 180° phase shift to the signal passing through, and give a balanced output. Regenerative feedback is balanced and is around all four stages of the amplifier to the balanced inputs. The floating bridge, in series with the feedback, has an impedance branch providing phase shift to frequencies off resonance, and a positive-coefficient-resistance branch controlling the feedback level and stabilizing the output amplitude.

The frequency-selective network consists of two impedances in series, which at resonance are almost equal. At resonance, the voltage at the junction is almost zero, but favoring the voltage obtained from the output of the amplifier opposite to the one being driven by the junction.

The amplitude-stabilizing network consists of two resistances in series, one a carbon resistance, the other a positive-temperature-coefficient tungsten lamp. During normal operation the voltage at the junction is almost zero, but favoring the amplifier output opposite to the input being driven. The input of each amplifier is thus essentially derived from the output of the opposite amplifier.

The very small bridge unbalance needs only to produce a voltage equal to the output divided by the gain of the amplifier to produce enough voltage across the bridge input to start oscillation. Only at one frequency does the signal applied to the bridge input appear on the opposite legs of the bridge without phase shift and cause regeneration; at all other frequencies, phase shift through the impedance networks prevents regeneration.

When an in-phase signal passing through the bridge starts the circuit into oscillation, the power in the signal heats the lamps, raising their resistance and bringing the bridge closer into balance. The increasing signal input increases the lamp resistance until it reaches an amplitude beyond which any further increase in lamp resistance would decrease the level of the input signal. At this level the circuit is stabilized, and it has been chosen by adjusting the division of resistance in this arm of the bridge to operate the amplifier tubes in the most linear portion of their operating curves.

The operation of the tuned circuits is described in the following paragraphs.

3.2 THE FREQUENCY-SELECTIVE BRIDGE

The frequency of oscillation is determined by the impedance branch of the bridge shown in Figure 3-1, which consists of an upper (series) leg and a lower (parallel) leg. Each leg consists of a variable capacitor for tuning and a synthesized impedance network consisting of a parallel group of series r-c elements. The tuning capacitors in each leg are "ganged" together. Oscillation occurs at the frequency whose phase is not shifted at the junction of the two legs. To explain the tuned network, first consider a simple bridge (shown in Figure 3-2) that uses a resistance instead of a synthesized impedance with the tuning capacitors. The frequency characteristic of such an r-c circuit is plotted on a reactance chart shown in Figure 3-3. At the frequency where the resistance curve intersects the reactance curve of the

capacitor, the signal voltage at the junction is in phase with the voltage applied to the ends of the two legs, and the overall circuit oscillates. As the capacitor is tuned through its 10:1 range, shown in the shadowed area, its reactance changes over a 10:1 range and the frequency of oscillation moves through a 10:1 range.

The resistive elements in the r-c pairs are replaced with an impedance network which has a slope between that of a resistance and that of a capacitive reactance as shown in Figure 3-4. The limits of the new tunable range occur where the impedance curve of the new network intersects the reactance curve of the tuning capacitor. The slope of the impedance line now gives a frequency range of 1000:1.

The impedance networks are synthesized from fixed resistances and capacitors. An essential requirement for these networks is that their impedance-phase angles be constant with frequency, since any phase variation shifts the frequency of oscillation from that set by the tuning capacitor. How well this requirement is met is basically a function of the number of elements used to synthesize the complex network. The poles and zeroes of the impedance of such a network lie on the negative real axis and are made to occur alternately. The asymptotic impedance lines corresponding to the array form the broken line shown in Figure 3-5, which changes from slope 0 to slope -1 at each frequency corresponding to a pole and from -1 to 0 at each frequency corresponding to a zero.

Segments of this broken line extend for one octave and the tilted segments for two, the "average" slope on the line will be -2/3. The actual impedance will be a very nearly straight line of this slope, as shown by the heavy line in Figure 3-5, and is reasonable to achieve since it requires only five resistances and four capacitors (six resistors and five capacitors in the CO-10-B). With this number of elements the synthesized impedance characteristic approximates the ideal over the desired frequency range within a few percent. Having an impedance slope almost constant gives a phase characteristic which is also constant over the rated frequency range.

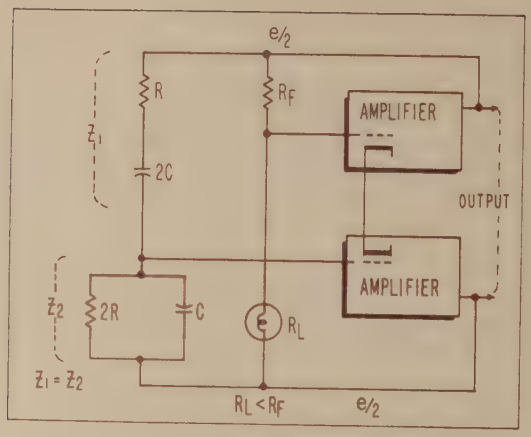


Figure 3-2.
Basic arrangement of positive feedback loop used in -hp- r-c oscillators.

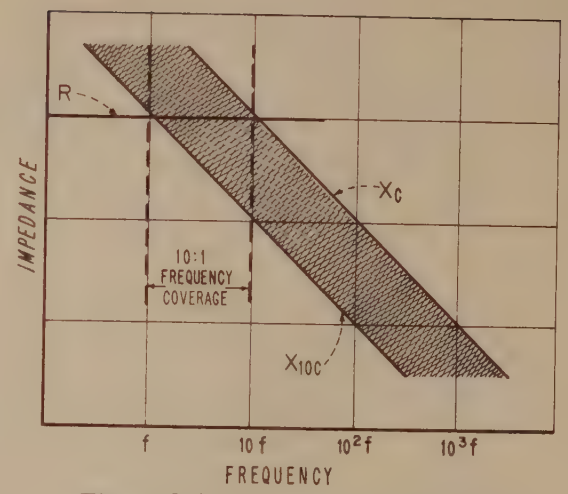


Figure 3-3.
Reactance plot of one r-c pair shown in the bridge in Figure 3-2.

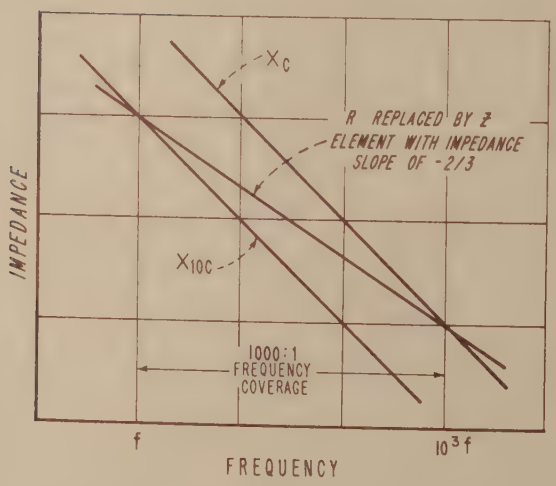


Figure 3-4.
Reactance plot of one z-c pair shown in the bridge in Figure 3-1.

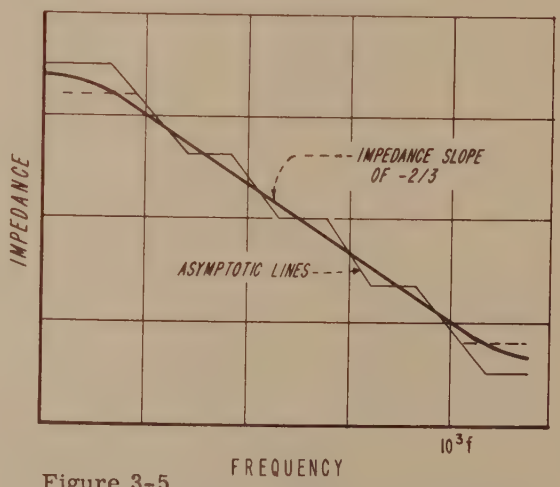


Figure 3-5.
The approximation of the -2/3 impedance with the asympotic lines of the synthesized impedance element in the bridge shown in Figure 3-1.

SECTION 4
SERVICE INSTRUCTIONS

4.1 INTRODUCTION

This section explains how to replace tubes and other components, and adjust the electrical circuits of the CO-10-A to be within specifications. The CO-10-A is constructed for long life; tube replacement will correct a majority of circuit malfunctions. Tube positions in the CO-10-A do not require selected tubes, but instrument performance should be checked after tube replacement to assure satisfactory performance. Circuit adjustment potentiometers provide the means for regaining original specifications following replacement of parts. Adjustments are straightforward and without complication if the procedures are followed. The material in this section is as follows:

4.2 Lubrication
4.3 Operating on 230 Volts
4.4 Replacing Tubes
4.5 Replacing the Bridge Lamp and Setting the Maximum Output Level
4.6 Replacing Parts in the Frequency-Selective Circuits
4.7 Calibrating the Dial and Setting the Frequency Response
4.8 Minimizing 60-Cycle Ripple and Low Frequency Distortion
4.9 Lubricating and Calibrating the Sweep Voltage Potentiometer
4.10 Calibrating the Sweep Rate Dial
4.11 Trouble-Shooting

4.2 LUBRICATION

The tuner drive mechanism uses life-time lubricated ball bearings which require no maintenance. Only the motor bearings should be oiled twice a year with light machine oil.

4.3 OPERATING ON 230 VOLTS

As shipped from the factory, the dual primary windings of the CO-10-A power transformer are connected in parallel for operation on 115-volt a-c lines. To reconnect the windings in series for operation on 230-volt lines, refer to the schematic diagram, remove the two jumpers "A" and "C" from the winding terminations and install jumper "B" between the two windings. Replace the 1.6-ampere fuse with a 0.8-ampere fuse, and the conversion is complete.

4.4 REPLACING TUBES

The tube positions in the CO-10 A do not require "selected" tubes and changing tubes does not affect the frequency-dial calibration or the output-level frequency response. However, to assure that a good tube is being installed, check the frequency-dial calibration, frequency response and level, distortion and ripple as deemed advisable. If any of these characteristics is out of specifications, it can probably be corrected by further tube replacement and/or minor circuit adjustment. If replacing a tube effects no improvement in sub-standard operation, return the old tube to the socket to avoid complicating the trouble-locating procedure. Instructions for each check and adjustment are given in following paragraphs; trouble shooting instructions are in para. 4.12.

4.5 REPLACING THE BRIDGE LAMP AND SETTING THE MAXIMUM OUTPUT LEVEL

The 10-watt, 115-volt lamp in the bridge circuit controls the operating level of the oscillator, holding it to the center of the tubes' operating characteristics (indicated by a maximum output of 1.2 volts). The lamp provides a positive-temperature-coefficient resistance operating at a very low temperature (no visible light) and ordinarily will not require replacement during the life of the instrument; it does not weaken or burn out.

When replacing a lamp, it may sometimes be necessary to select a lamp that has an average resistance value. In unusual cases, a lamp with an odd characteristic may introduce harmonic distortion, and should not be used.

To set the oscillator output level after replacing the lamp, refer to Figure 4-1 and proceed as follows:

4.5.1 Remove the instrument top plate; connect to a power source, turn on and allow to warm up for one minute.

4.5.2 Set the frequency dial to 100 cycles, the OUTPUT control to maximum output.

4.5.3 Connect an accurate high-resistance a-c voltmeter to the output terminals to measure the signal level.

4.5.4 If necessary, adjust R29 to obtain 1.2 volts.

4.5.5 Check flatness of output across the band as described in paragraph 4.7. If the output level remains constant within ±1 db, the adjustment is completed.

4.6 REPLACING PARTS IN THE FREQUENCY-SELECTIVE CIRCUITS

When replacing any part in the frequency-selective network, use exact duplicate parts. The tuning capacitor is specially built and must be purchased from Dymec, Inc.; all other parts may be purchased from their manufacturers. All electrical parts in the circuit have a 1% or better tolerance; some values must be adjusted by measurement of circuit operation.

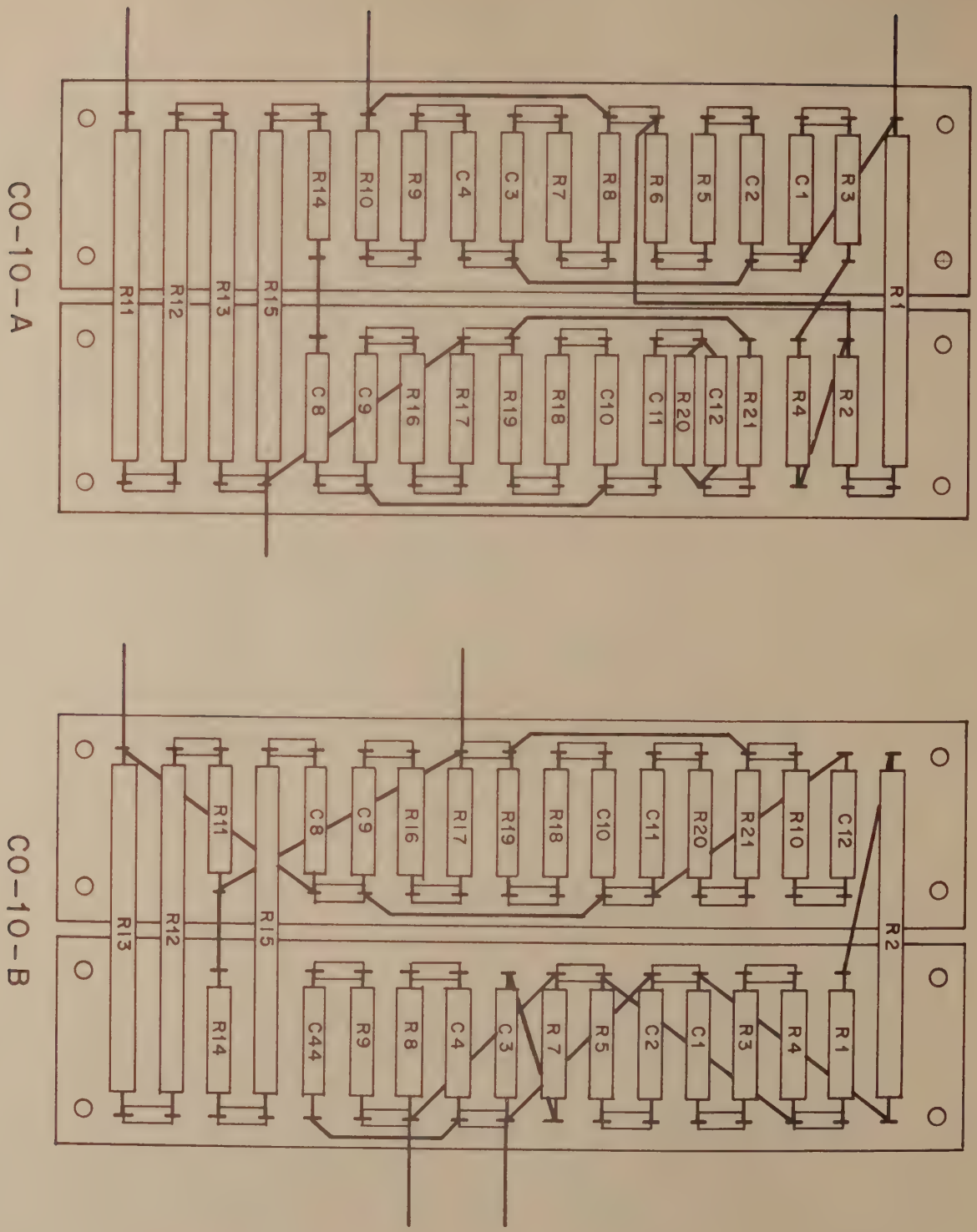


Diagram showing locations of parts in the frequency-selective networks

Adjusted values are indicated by asterisks; value actually used may differ from that shown in the schematic diagram. When this is the case, replace with the value indicated by the lettering and color coding on the resistors themselves instead of the values shown in the diagram.

Following any work on the frequency-determining circuits, check the frequency dial calibration and frequency response as instructed in para. 4.7. Many parts, if replaced by duplicate parts, will not change the dial calibration or frequency response. Replacement of parts such as the tuning capacitor and trimmer capacitors requires complete recalibration. Since the original dial is hand calibrated to a specific tuning capacitor, it is possible that a new capacitor may require a new dial to obtain original accuracy. Note that the specification for frequency dial calibration accuracy is an overall specification for all conditions of operation; actually, with an ambient temperature of 25°C. and a line voltage of 115 vac the dial is originally calibrated to within ±1%.

4.7 CALIBRATING THE FREQUENCY DIAL AND SETTING THE FREQUENCY RESPONSE

Only the high-frequency end of the dial is adjustable by trimmers; the low end is fixed and is adjustable by first slipping the frequency dial on its shaft and secondly by shifting tuning-capacitor plates. Adjustment of the high-end dial calibration also affects the frequency response of the oscillator. Two interactive trimmer capacitors are provided so that together they can be adjusted to give both accurate dial calibration and flat frequency response, at the high frequency end of the dial. The low end is affected slightly by the high-end adjustments and must be rechecked after setting the high end. If necessary, the process should be repeated until both high and low ends are satisfactory.

To calibrate the frequency dial, proceed as follows:

4.7.1 Connect the CO-10-A to a power source, turn on and allow to warm up for approximately 20 minutes.

4.7.2 Connect an electronic counter and an a-c voltmeter having a calibrated frequency response and accuracy from 5 to 5000 cycles per second (CO-10-B, 10 to 10,000 cps) to the output of the oscillator. The following measurements should be accurate to within ±1% (counter must measure "period" at 5 cps).

4.7.3 Set the oscillator to 5 cycles per second (CO-10-B, 10 cps) and note both the dial calibration accuracy and the output voltage level, which if necessary, must be set close to 1.2 volts maximum as instructed in para. 4.5. Set the OUTPUT control to obtain 0.9 volt output.

4.7.4 Set the oscillator to 5000 cycles per second (CO-10-B, 10,000 cps) and note both the dial calibration and the output-voltage level.

4.7.5 If necessary loosen the set screws in the frequency dial and slip the dial on its shaft to bring dial into accurate calibration at 5 cycles per second.

4.7.6 If necessary, through the adjustment holes in the left-hand side of the chassis, simultaneously adjust trimmers C10 and C21 to bring the dial into accurate calibration at 5000 cps and to make the output voltage equal to that noted in step 3 at 5 cps.

NOTE: The top and bottom plates must be on in order to accurately check the frequency-dial calibration.

The simplest way to do this is to first adjust either trimmer to flatten the frequency response without regard to dial calibration. Then, noting the distance on the dial that it must be moved to bring into calibration, adjust either trimmer to move the dial half of this distance, then adjust the other trimmer to move the dial the rest of the way into accurate calibration.

4.7.7 Recheck the calibration and output voltage at 5 cps.

4.7.8 If necessary repeat the above procedure, refining the adjustments to obtain the best overall dial calibration.

4.7.9 If mid-band dial calibrations require adjustment, the plate of the tuning capacitor must be very slightly shifted to give a small change in capacity. Shift only the two outer plates of each section; shift only the portion of the rotor plates which are engaged at frequency to be calibrated; to raise frequency, decrease capacity by spreading plates outward; to lower it, increase capacity by pressing them closer together; shift the plates equally in each section, then repeat the high and low end calibration procedure.

4.8 MINIMIZING 60-CYCLE RIPPLE AND LOW-FREQUENCY DISTORTION

The output signal from the CO-10-A should not contain more than 1% total harmonic distortion at any frequency and power level, while 60-cycle ripple should be less than 0.1% of the output level.

Distortion and ripple are predominantly caused by poor tubes. In some cases one of the two lamps in the frequency-selective bridge can cause distortion, and is cured by replacing the faulty lamp. The tube most likely to cause distortion is V1, since one of its grids operates with a 262-megohm return resistor (CO-10-B, 182 megohm) and consequently cannot be permitted grid current which would develop grid bias.

An adjustment is provided for minimizing the 60-cycle ripple. Line-frequency ripple in the output is minimized by setting the oscillator frequency to 55 cps and measuring distortion in the output on a distortion meter such as the Hewlett-Packard Model 330B, and adjusting R64 to obtain minimum distortion.

An adjustment is provided for minimizing distortion at low frequencies. The balance of the output stage can be improved, thus reducing second harmonic content, by setting the oscillator to 20 cycles or below, and measuring the harmonic content in the output with a distortion meter such as the -hp- 330B, and adjusting R65 for minimum distortion.

4.9 LUBRICATING AND CALIBRATING THE SWEEP VOLTAGE POTENTIOMETER

The only periodic maintenance the potentiometer assembly requires is lubrication once or twice a year, depending upon amount of use. Lubricate the ball bearings with a medium-viscosity machine oil. Lubricate the gears with MOLUB-ALLOW #1, or light grease.

Potentiometer linearity is measured at the factory and set by precision-resistor shunts to obtain an output voltage which is linear with the logarithm of the output frequency to within ±5%. No adjustment should normally be needed to maintain this accuracy. To measure the linearity of the output voltage, refer to schematic diagram of potentiometer connections and proceed as follows:

4.9.1 Turn on the instrument and allow it to warm up for 10 minutes.

4.9.2 Connect a d-c vacuum-tube voltmeter from the ground terminal marked (-) to the center-tap terminal marked (CT).

4.9.3 Measure and plot the potentiometer output voltages at frequencies of 5 cps, 20 cps, 50 cps, 100 cps, 400 cps, 1000 cps, 2000 cps, and 5000 cps on semi-log graph paper.

4.9.4 Draw a straight line through the 5-cycle and the 5000-cycle voltage points. The plotted points should not deviate from this straight line by more than ±5%.

To set the potentiometer arm in relation to the tuning capacitor, set the oscillator frequency to 13.3 cycles/-second. Connect an ohmmeter to Tap C and J, and turn the potentiometer shaft to obtain 0 or minimum resistance. Tighten the set screws in the potentiometer gear.

4.10 CALIBRATING THE SWEEP RATE DIALS

Sweep rate is adjusted by two front-panel controls, one a gear changer, the other a rheostat. The gear changer gives eight basic fixed speeds; the rheostat gives continuous adjustment of speed between the basic sweep rates. There are two variable resistors which permit calibrating the end points of the SWEEP RATE VERNIER control, which in turn also calibrates the SWEEP RATE DEGREES PER MINUTE dial. To calibrate the sweep rate controls, proceed as follows:

4.10.1 Remove the instrument bottom plate; connect to a power source, and turn on the power switch; turn the motor switch off.

4.10.2 Set the limiting dials on the frequency dial to permit 300° of rotation.

4.10.3 Set the SWEEP RATE control to 300 (degrees per minute).

4.10.4 Set the SWEEP RATE VERNIER to 2.0X.

4.10.5 Measure with a stop watch the time required for one sweep in both cw and ccw directions, which should be 30 seconds each way.

*4.10.6 If necessary, adjust R87 to obtain sweep time of 30 seconds.

4.10.7 Set the SWEEP RATE VERNIER to 1.0X, which should increase the sweep time to 1 minute.

4.10.8 If necessary, adjust R89 to obtain a sweep time of 1 minute.

4.10.9 Recheck the 2.0X SWEEP RATE VERNIER setting and if necessary re-adjust for best accuracy.

* NOTE: The sweep rates for cw and ccw directions may differ slightly. Use the mean time for adjustment settings.

4.11 TROUBLE-SHOOTING

Always begin trouble-shooting by a visual inspection of the most obvious things first, such as the instrument set-up; observe the connections to the power source and to the equipment being fed; check the line fuse and control settings, and the method of operation. If there is a circuit failure, look for signs of damage such as a broken connection, signs of overheating, loose tubes, and so on. Check tubes by replacement or with a tube checker. Do not replace tubes unnecessarily. Analyze the symptoms of the circuit malfunction in an attempt to localize the failure to a specific circuit. If necessary, measure voltages and/or resistances at tube-socket terminals and compare with the values given in the following chart. These values are nominal, measured on an average instrument known to be operating satisfactorily, and can be used as a guide. Due to the differences in conduction between tubes of the same type, d-c voltages on the plates and screens may vary considerably in different CO-10 oscillators. For further analysis, measure frequency dial calibration, output voltage vs frequency across the band, ripple level, and distortion at low and high frequencies, and compare with the values given in the specifications for the instrument.

VOLTAGE & RESISTANCE CHART

Tube	Pin	Element	Ohms	DC Volts	AC Volts
V1	1	Plate	300K	+200	0
	2	Grid	300M	+1.4	.06
	3, 8	Cathodes	80K	+2.6	.04
	4, 5	Heater	12	----	3.15
	6	Plate	300K	+200	0
	7	Grid	27K	+1.3	.06
	9	Heater	12	----	3.15
V2, 3	1	Cathode	80K	+2.6	.04
	2	Grid	0	0	0
	3	Plate	320K	+180	.92
	4	Heater	12	----	3.15
	5	Heater	12	----	3.15
	6	Cathode	1K	+2.5	.7
	7	Grid	3.6M	-1.2	.92
	8	Screen	380K	+112	.065
	9	Plate	350K	+104	26
V4, 5	1	Grid	2.4M	-22	26
	2	Heater	12	----	3.15
	3	Cathode	26K	+1.05	20
	5	Plate	300K	+172	7.8
	7	Heater	12	----	3.15
	8	Screen	300K	+172	7.6
V6, 7	1	Cathode	300K	+200	.025
	2, 7	Grid	1.3M	+192	.68
	3	Heater	Inf.	----	----
	4, 5	Heater	Inf	----	----
	9	Plate	300K	+300	3.7
V8	1	Grid	340K	-48	.003
	2, 7	Cathode	400K	-45	.002
	3	Heater	12	----	3.15
	4	Heater	12	----	3.15
	5	Plate	1.3M	+192	.68
	6	Screen	370K	+21	.012
V9	1, 5	Anode	400K	-45	.002
	2, 4, 7	Cathode	24K	-132	.002

Oscillator set to 100 cps, 1 volt out.

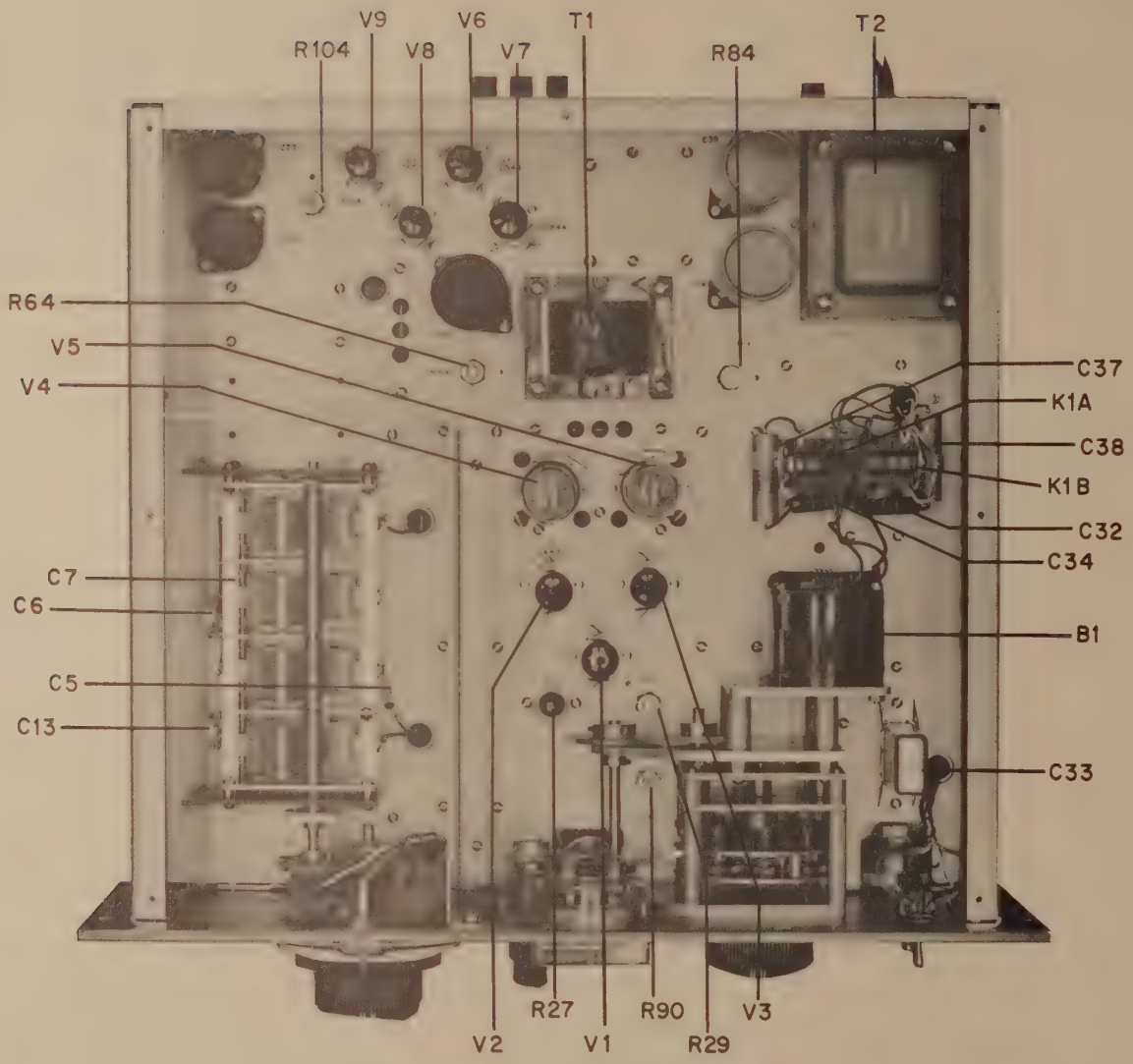


Figure 4-1. Top view of chassis showing location of parts

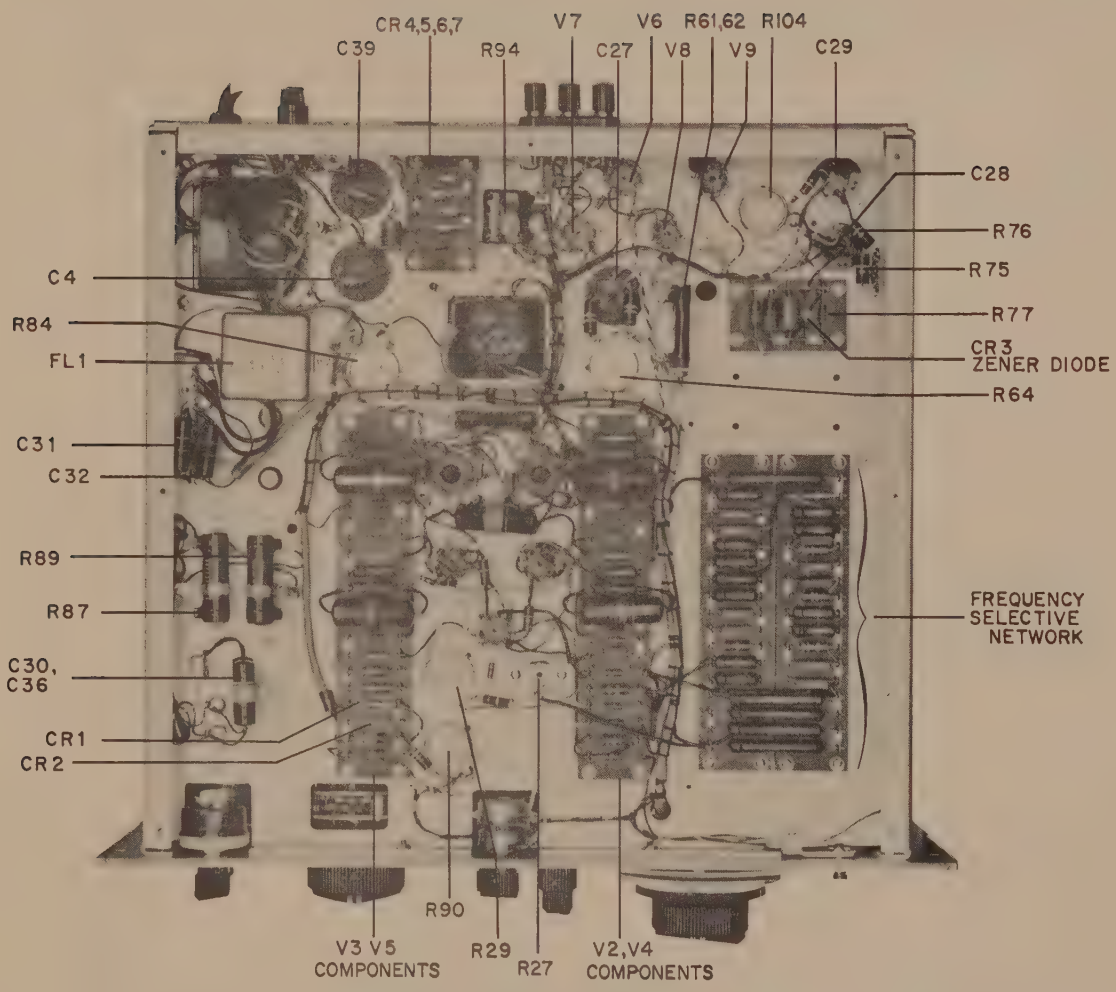


Figure 4-2. Bottom view of chassis showing location of parts

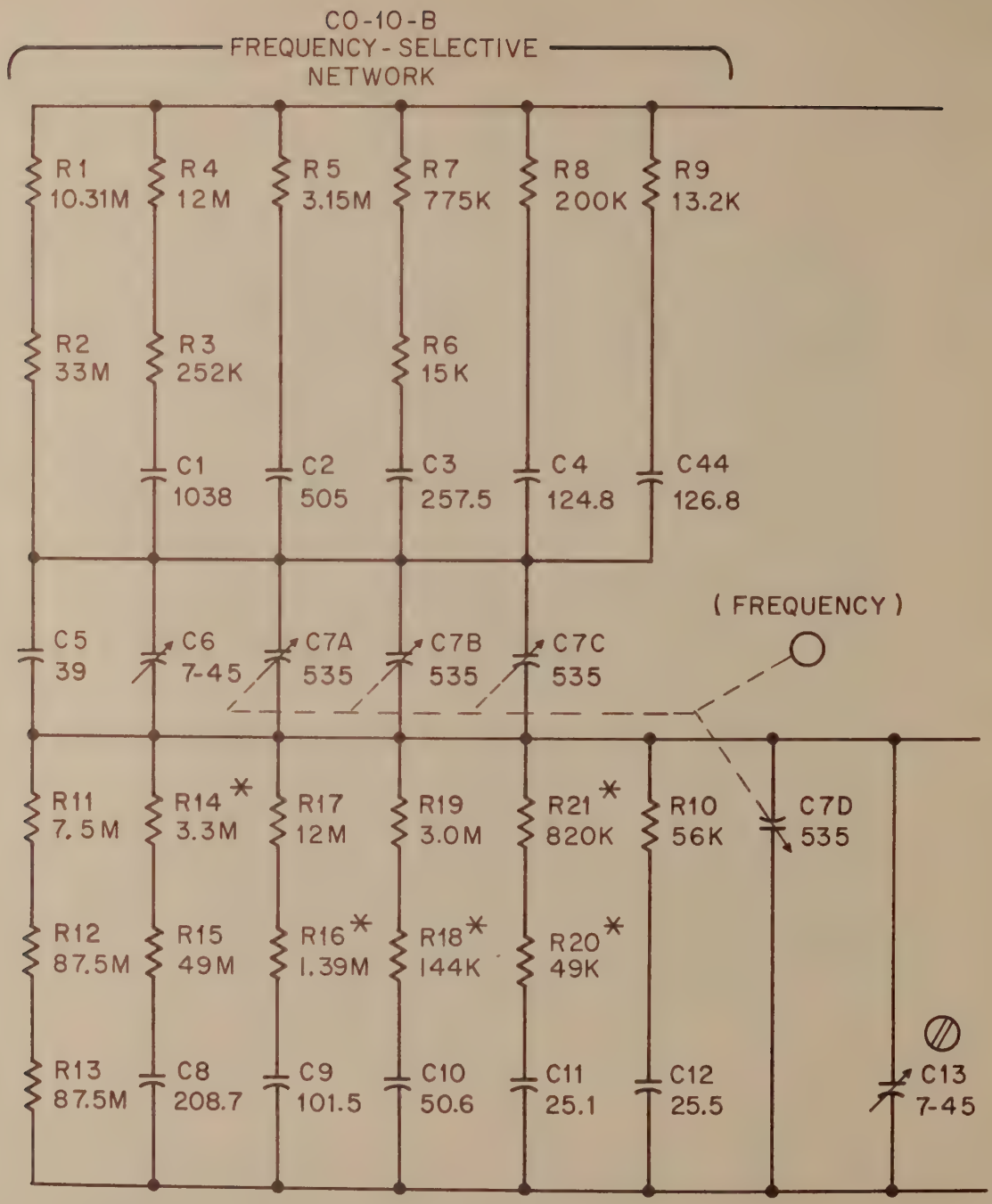


Figure 4-3. Schematic diagram for the Frequency Selective Network only in the CO-10-B Cycling Oscillator

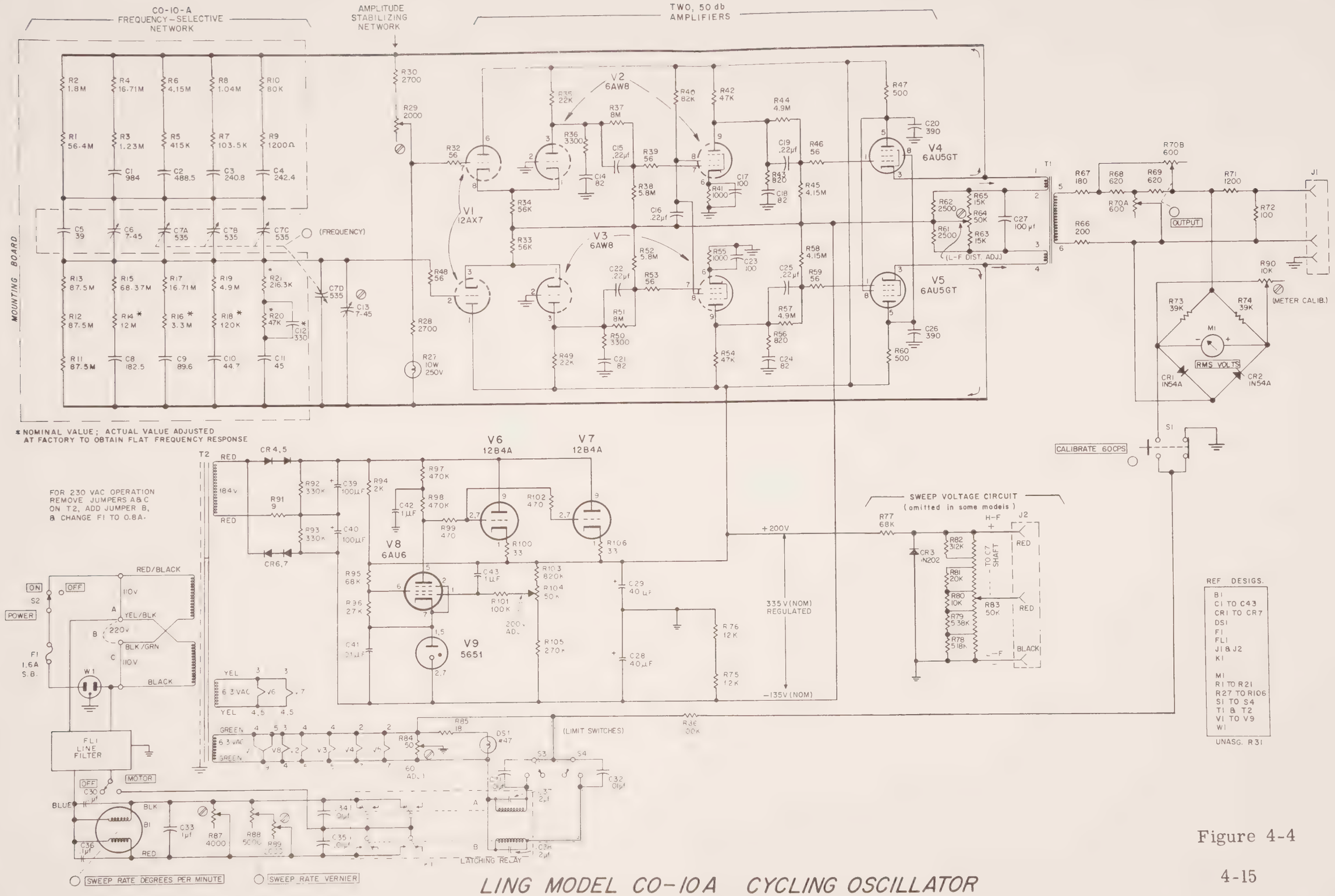
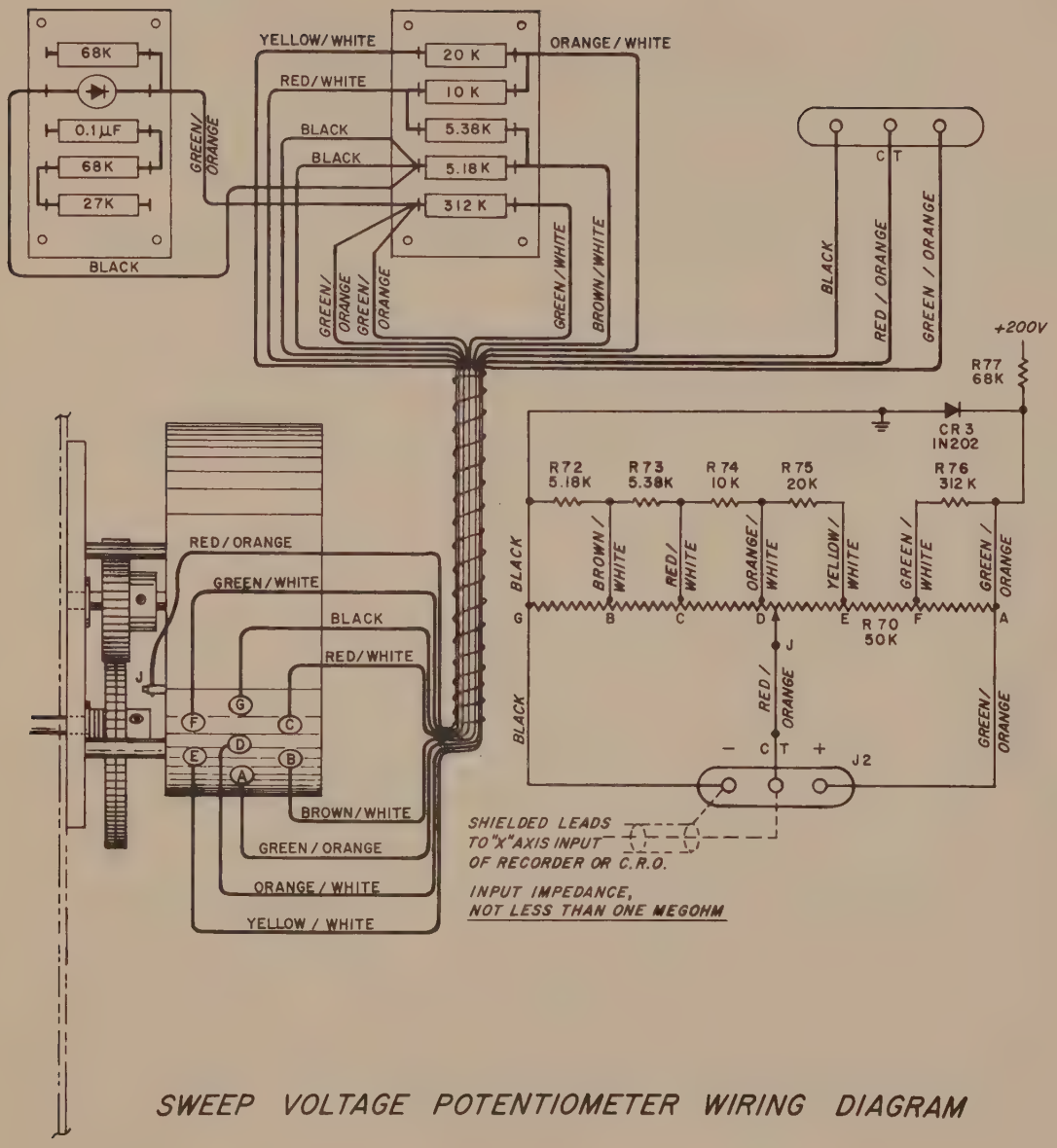


Figure 4-4

LING MODEL CO-10A CYCLING OSCILLATOR

SERIALS 635 & ABOVE



SWEEP VOLTAGE POTENTIOMETER WIRING DIAGRAM

Figure 4-5

SECTION 5
TABLE OF REPLACEABLE PARTS

Any changes in the Table of Replaceable Parts will be listed on a Production Change sheet at the front of this manual. The oscillator used in the CO-10-A and CO-10-B is manufactured by Dymec, a Division of Hewlett-Packard Co., Palo Alto, California.

If a part in the Table has only a Dymec stock number, it is a special part that can be obtained only from Dymec. If a part has another manufacturer's stock number, it can be obtained directly from that manufacturer. Manufacturers' code letters are listed on the last page. In most cases parts provided by manufacturers other than those listed can be used if they have the same electrical and physical characteristics, and are equal or better in quality.

To order a part from Dymec, give the instrument model and serial numbers, a description of the part, and the Dymec stock number.

As noted on the schematic diagrams, the electrical values of certain parts are selected to compensate for variations in other components, wiring capacitance, etc. In some instruments a selected part may be omitted (e.g. a selected resistor might be a wire or an open circuit). The schematic diagram gives the nominal value of these parts. When replacing, use the original value of the replaced part.

REF. DESIG.	DESCRIPTION	DYMEC STOCK NO.	MFR. * & MFRS. DESIG.	QTY.	1-YR. SPA•
B1	Motor, induction, geared, 17 rpm	None	Bodine, KCI-22RC		
C1**	Capacitor: fixed, mica, 984uuf, 1/4%, 500V	1003-0025	Z, type KR	1	1
C2**	Capacitor: fixed, mica, 488.5uuf, 1/4%, 500V	1003-0024	Z, type KR	1	1
C3**	Capacitor: fixed, mica, 240.8uuf, 1/4%, 500V	1003-0022	Z, type KR	1	1
C4**	Capacitor: fixed, mica, 242.4uuf, 1/4%, 500V	1003-0023	Z, type KR	1	1
C5	Capacitor: fixed, ceramic, 39uuf, 5%, 500V	1005-0001	K, type C1-2, NPO	1	1
C6, 13	Capacitor: variable, air, 7-45uuf	1001-0001	L, TS2A	2	1
C7	Capacitor: variable, air, 12.4-535uuf, four section	1001-0002	L, TS2A	1	1
C8**	Capacitor: fixed, mica, 182.5uuf, 1/2%, 500V	1003-0021	Z, type KR	1	1
C9**	Capacitor: fixed, mica, 89.6uuf, 1/2%, 500V	1003-0020	Z, type KR	1	1
C10**	Capacitor: fixed, mica, 44.7uuf, 1/2%, 500V	1003-0018	Z, type KR	1	1
C11**	Capacitor: fixed, mica, 45uuf, 1/2%, 500V	1003-0019	Z, type KR	1	1
C12**	Capacitor: fixed, mica, 330uuf, 10%, 500V (nominal value)	1002-0010	Z, K1333	1	1
C14, 18, 21, 24	Capacitor: fixed, mica, 82uuf, 10%, 500V	1002-0004	J, 22A5Q82	4	1
C15, 16, 19, 22, 25	Capacitor: fixed, paper, 0.22uf, 5%, 400V	1007-0015	CC, 109P22494	5	2
C17, 23	Capacitor: fixed, mica, 100uuf, 10%, 500V	1002-0011	Z, K1310	2	1
C20, 26	Capacitor: fixed, mica, 390uuf, 10%, 500V	1002-0020	V, type O	2	1
C27	Capacitor: fixed, non-polar electrolytic, 100uf, 100V	1013-0002	CC, D17345	1	1
C28, 29	Capacitor: fixed, electrolytic, 40uf, 450V	1013-0004	CC, D16653	2	1
C30, 36	Capacitor: fixed, paper, 0.1uf, 10%, 400V	1007-0010	CC, 109P10494	2	1
C31, 32, 34, 35	Capacitor: fixed, paper, 0.01uf, 10%, 600V	1007-0006	CC, 109P10356	4	1
C33	Capacitor: fixed, paper, 1.0uf, 10%, 400V	1007-0029	CC, 4TM-MI	1	1
C37, 38	Capacitor: fixed, paper, 2.0uf, 10%, 200V	1007-0038	AJ, XMF-86-15-20	2	1
C39, 40	Capacitor: fixed, electrolytic, 100uf, 450V	1010-0009	X, FP-150	2	1
C41	Capacitor: fixed, ceramic, 0.01uf, 1000V	1005-0002	K, type BPD	1	1
C42, 43	Capacitor: fixed, paper, 0.1uf, 20%, 600V	1008-0001	Tex. Cap., type 25	2	1
CR1, 2	Diode: 1N54A	1282-0008	EE	2	1
CR3	Diode, reference-type: 1N202	1281-0003	Hoffman, 1N202	1	1
	**Applies only to CO-10-A. See sub-list for corresponding part for CO-10-B.				

* Manufacturers' code letters on last page. • Recommended 1-yr. isolated-use spares per MIL-E-17362A.

REF. DESIG.	DESCRIPTION	DYMEC STOCK NO.	MFR. * & MFRS. DESIG.	QTY.	1-YR. SPA•
CR4-7	Diode, silicon	1281-0014	BV, SD-94	4	1
DS1	Lamp, incandescent, 6-volt, 150 ma	2870-0004	N, No. 47	1	1
F1	Fuse, 1.6-ampere, slo-blo	1955-0012	E, MDL-1.6	1	1
FL1	Filter, line noise, 2-amperes	1040-0001	J, 1F54	1	1
J1, 2	Terminal, binding post, black red	8023-0001 8023-0002	HP	2	1
K1, 2	Relay, latching, double solenoid, 6-volt ac	1314-0001	CT, KB-17AY	2	1
M1	Meter, 200ua, special dial reading 0 to 2 vrms	1403-0001	Beede, type 2PL	1	1
R1**	Resistor: fixed, carbon film, 56.4M, 1%, 2W	1085-0001	NN, type DC-2	1	1
R2**	Resistor: fixed, composition, 1.8M, 5%, 1W	1068-1855	B, GB1855	1	1
R3**	Resistor: fixed, carbon film, 1.23M, 1%, 1W	1082-0011	NN, type DC-1	1	1
R4, 17**	Resistor: fixed, carbon film, 16.71M, 1%, 2W	1082-0017	NN, type DC-2	1	1
R5**	Resistor: fixed, carbon film, 415K, 1%, 1W	1082-0007	NN, type DC-1	1	1
R6**	Resistor: fixed, carbon film, 4.15M, 1%, 1W	1082-0012	NN, type DC-1	1	1
R7**	Resistor: fixed, carbon film, 103.5K, 1%, 1W	1082-0004	NN, type DC-1	1	1
R8**	Resistor: fixed, carbon film, 1.04M, 1%, 1W	1082-0010	NN, type DC-1	1	1
R9**	Resistor: fixed, composition, 1.2K, 5%, 1W	1068-1225	B, GB1225	1	1
R10**	Resistor: fixed, carbon film, 80K, 1%, 1W	1082-0003	NN, type DC-1	1	1
R11**, 12, 13	Resistor: fixed, carbon film, 87.5M, 1%, 2W	1085-0003	NN, type DC-2	3	1
R14**	Resistor: fixed, carbon film, 12M, 1%, 1W (nominal value)	1082-0016	NN, type DC-1	1	1
R15**	Resistor: fixed, carbon film, 68.37M, 1%, 2W	1085-0002	NN, type DC-2	1	1
R16**	Resistor: fixed, composition, 3.3M, 5%, 1W (nominal value)	1068-3355	B, GB3355	1	1
R18**	Resistor: fixed, composition, 120K, 5%, 1W (nominal value)	1068-1245	B, GB1245	1	1
R19**	Resistor: fixed, carbon film, 4.9M, 1%, 1W	1082-0013	NN, type DC-1	1	1
	**Applies only to CO-10-A. See sub-list for corresponding part for CO-10-B.				

* Manufacturers' code letters on last page. • Recommended 1-yr. isolated-use spares per MIL-E-17362A.

REF. DESIG.	DESCRIPTION	DYMEC STOCK NO.	MFR. * & MFRS. DESIG.	QTY.	1-YR. SPA•
R20**	Resistor: fixed, composition, 47K, 5%, 1W (nominal value)	1068-4735	B, GB4735	1	1
R21**	Resistor: fixed, carbon film, 216.3K, 1%, 1W (nominal value)	1082-0005	NN, type DC-1	1	1
R26	Resistor: fixed, composition, 2200 ohms, 5%, 1W	1068-2225	B, GB2225	1	1
R27	Lamp, incandescent, 250v, 10W	2870-0001	N, 10S6/10-250	1	1
R28	Resistor: fixed, composition, 2700 ohms, 5%, 1W	1068-2725	B, GB2725	1	1
R29	Resistor: variable, composition, 2000 ohms, 20%, 1W	1202-0001	I, 37-20005	1	1
R30	Resistor: fixed, composition, 2700 ohms, 5%, 1W	1068-2725	B, GB2725	1	1
R32, 39, 46, 48, 53, 59	Resistor: fixed, composition, 56 ohms, 5%, 1/2W	1067-5605	B, EB5605	6	2
R33, 34	Resistor: fixed, composition, 56K, 5%, 1W	1068-5635	B, GB5635	2	1
R35, 49	Resistor: fixed, composition, 22K, 5%, 1W	1068-2235	B, GB2235	2	1
R36	Resistor: fixed, composition, 3.3K, 5%, 1W	1068-3325	B, GB3325	1	1
R37, 51	Resistor: fixed, carbon film, 8M, 1%, 1W	1082-0027	NN, type DC-1	2	1
R38, 52	Resistor: fixed, carbon film, 5.8M, 1%, 1W	1082-0050	NN, type DC-1	2	1
R40	Resistor: fixed, composition, 82K, 5%, 1W	1068-8235	B, GB8235	1	1
R41, 55	Resistor: fixed, composition, 1K, 5%, 1/2W	1067-1025	B, EB1025	2	1
R42, 54	Resistor: fixed, composition, 47K, 5%, 1W	1068-4735	B, GB4735	2	1
R43, 56	Resistor: fixed, composition, 820 ohms, 5%, 1/2W	1067-8215	B, EB8215	2	1
R44, 57	Resistor: fixed, carbon film, 4.9M, 1%, 1W	1082-0013	NN, type DC-1	2	1
R45, 58	Resistor: fixed, carbon film, 4.15M, 1%, 1W	1082-0012	NN, type DC-1	2	1
R47, 60	Resistor: fixed, wire-wound, 500 ohms, 10%, 20W	1162-0006	S, type CN20	2	1
R50	Resistor: fixed, composition, 3.3K, 5%, 1/2W	1067-3325	B, EB3325	1	1
R61, 62	Resistor: fixed, wire-wound, (matched pairs), 2.5K, 10%, 10W	1161-0006	S, type C-10	1	1
R63, 65	Resistor: fixed, composition, 15K, 10%, 2W	1069-1531	B, HB1531	2	1
R64	Resistor: variable, composition, 50K, 20%, 1/2W	1201-0001	G, type 37	1	1
R66	Resistor: fixed, composition, 200 ohms, 5%, 1/2W	1067-2015	B, EB2015	1	1
R67	Resistor: fixed, composition, 180 ohms, 5%, 1/2W	1067-1815	B, EB1815	1	1
	**Applies only to CO-10-A. See sub-list for corresponding part for CO-10-B.				

* Manufacturers' code letters on last page. • Recommended 1-yr. isolated-use spares per MIL-E-17362A.

REF. DESIG.	DESCRIPTION	DYMEC STOCK NO.	MFR. * & MFRS. DESIG.	QTY.	1-YR. SPA.•
R68, 69	Resistor: fixed, composition, 620 ohms, 5%, 1/2W	1067-6215	B, EB6215	2	1
R70	Resistor: variable, Delta T-Pad, 600 ohms per section, 20%, 2W	1203-0001	B, JJ59160	1	1
R71	Resistor: fixed, composition, 1. 2K, 5%, 1W	1068-1225	B, GB1225	1	1
R72	Resistor: fixed, composition, 100 ohms, 5%, 1/2W	1067-1015	B, EB1015	1	1
R73, 74	Resistor: fixed, composition, 39K, 5%, 1W	1068-3935	B, GB3935	2	1
R75, 76	Resistor: fixed, composition, 12K, 5%, 2W	1069-1235	B, HB1235	2	1
R77	Resistor: fixed, composition, 68K, 5%, 2W	1069-6835	B, HB6835	1	1
R78	Resistor: fixed, carbon film, 5. 18K, 1%, 1/2W	1076-0034	NN, type DC-1/2A	1	1
R79	Resistor: fixed, carbon film, 5. 38K, 1%, 1/2W	1076-0035	NN, type DC-1/2A	1	1
R80	Resistor: fixed, carbon film, 10K, 1%, 1/2W	1076-0036	NN, type DC-1/2A	1	1
R81	Resistor: fixed, carbon film, 20K, 1%, 1/2W	1076-0037	NN, type DC-1/2A	1	1
R82	Resistor: fixed, carbon film, 312K, 1%, 1/2W	1076-0038	NN, type DC-1/2A	1	1
R83	Resistor: variable, wire-wound, 50K, 4W	1220-0001	Paeco, 6021	1	1
R84	Resistor: variable, wire-wound, 50 ohms, 10%, 3W	1219-0001	I, type 43-50	1	1
R85	Resistor: fixed, composition, 100K, 5%, 1/2W	1067-1045	B, EB1045	1	1
R87	Resistor: variable, wire-wound, 4K, 25W	1236-0001	AU, 0381	1	1
R88	Resistor: variable, wire-wound, 5K, 25W	1230-0001	AU, 0162	1	1
R89	Resistor: variable, wire-wound, 2K, 25W	1236-0002	AU, 0377	1	1
R90	Resistor: variable, composition, 10K, 10%, 2W	1203-0012	B, type J	1	1
R91	Resistor: fixed, wire-wound, 9 ohms, 10%, 5W	1160-0008	S, TA-5	1	1
R92, 93	Resistor: fixed, composition, 330K, 5%, 1W	1068-3345	B, GB3345	2	1
R94	Resistor: fixed, wire-wound, 2K, 5%, 30W	1164-0001	I, 5ZT	1	1
R95	Resistor: fixed, composition, 68K, 5%, 2W	1069-6835	B, HB6835	1	1
R96	Resistor: fixed, composition, 27K, 5%, 1W	1068-2735	B, GB2735	1	1
R97, 98	Resistor: fixed, composition, 470K, 5%, 1/2W	1067-4745	B, EB4745	2	1
R99, 102	Resistor: fixed, composition, 470 ohms, 5%, 1/2W	1067-4715	B, EB4715	2	1
R100, 106	Resistor: fixed, composition, 33 ohms, 5%, 1/2W	1067-3305	B, EB3305	2	1
R101	Resistor: fixed, composition, 100K, 5%, 1/2W	1067-1045	B, EB1045	1	1
R103	Resistor: fixed, composition, 820K, 5%, 1W	1068-8245	B, GB8245	1	1
R104	Resistor: variable, composition, 50K, 10%, 2W	1203-0024	B, type J	1	1

* Manufacturers' code letters on last page. • Recommended 1-yr. isolated-use spares per MIL-E-17362A.

REF. DESIG.	DESCRIPTION	DYMEC STOCK NO.	MFR. * & MFRS. DESIG.	QTY.	1-YR SPA.•
R105	Resistor: fixed, composition, 270K, 5%, 1W	1068-2745	B, GB2745	1	1
S1	Switch, pushbutton	1852-0001	KK, 1003	1	1
S2, 5	Switch, toggle, SPST	1850-0001	R.H. Fisher, 80994H	2	1
S3, 4	Switch, sensitive, SPDT	1853-0002	AQ, 11SM1	2	1
T1	Transformer, audio (5-5000cps)	1576-0001	Paeco, 912-38	1	1
T2	Transformer, power	1575-0021	Paeco, 9083	1	1
V1	Tube, electron: 12AX7	1270-0010	CS	1	1
V2, 3	Tube, electron: 6AW8A	1270-0042	ZZ	2	2
V4, 5	Tube, electron: 6AU5GT	1270-0014	ZZ	2	2
V6, 7	Tube, electron: 12B4A	1270-0040	ZZ	2	2
V8	Tube, electron: 6AU6	1270-0015	ZZ	1	1
V9	Tube, electron: 5651	1270-0031	ZZ	1	1
W1	Cable, power, 3-wire, NEMA plug	3170-0001	TT, KH-3088	1	1
	Coupler, flexible	3500-0001	James Millen, 39016		
	Window, dial	8022-0001	HP		
	Insulator, coupler, nylon	150-9A	HP		
	Coupling, 1/4" shaft	150-9B	HP		
	Knob, clutch release	B5329-3045	CV		
	Knob, frequency control		Ling Elect., CA-225-2-2		
	Knob, pointer, sweep rate vernier output control		Ling Elect., CA-70-S-2		
	Knob, sweep rate control	A5329-3016	CV		
	Knob, skirt, frequency control	B5329-3025	CV		
	Knob, manual drive	B5329-3019	CV		

* Manufacturers' code letters on last page. • Recommended 1-yr. isolated-use spares per MIL-E-17362A.

REF. DESIG.	DESCRIPTION	DYMEC STOCK NO.	MFR. * & MFRS. DESIG.	QTY.	1-YR. SPA•
	Resistor board "C" sub-list -- CO-10-B				
C1	Capacitor: fixed, mica, 1038uuf, 1/2%, 500V	1003-0074	Z, type KR	1	1
C2	Capacitor: fixed, mica, 505uuf, 1/2%, 500V	1003-0075	Z, type KR	1	1
C3	Capacitor: fixed, mica, 257.5uuf, 1/2%, 500V	1003-0076	Z, type KR	1	1
C4	Capacitor: fixed, mica, 124.8uuf, 1/2%, 500V	1003-0079	Z, type KR	1	1
C8	Capacitor: fixed, mica, 208.7uuf, 1/2%, 500V	1003-0077	Z, type KR	1	1
C9	Capacitor: fixed, mica, 101.5uuf, 1/2%, 500V	1003-0080	Z, type KR	1	1
C10	Capacitor: fixed, mica, 50.6uuf, 1/2%, 500V	1003-0081	Z, type KR	1	1
C11	Capacitor: fixed, mica, 25.1uuf, 1/2%, 500V	1003-0083	Z, type KR	1	1
C12	Capacitor: fixed, mica, 25.5uuf, 1/2%, 500V	1003-0082	Z, type KR	1	1
C44	Capacitor: fixed, mica, 126.8uuf, 1/2%, 500V	1003-0078	Z, type KR	1	1
R1	Resistor: fixed, carbon film, 10.31M, 1%, 1W	1082-0015	NN, type DC-1	1	1
R2	Resistor: fixed, carbon film, 33M, 1%, 2W	1085-0005	NN, type DC-2	1	1
R3	Resistor: fixed, carbon film, 252K, 1%, 1W	1082-0006	NN, type DC-1	1	1
R4, 17	Resistor: fixed, carbon film, 12M, 1%, 1W	1082-0016	NN, type DC-1	2	1
R5	Resistor: fixed, carbon film, 3.15M, 1%, 1W	1082-0061	NN, type DC-1	1	1
R6	Resistor: fixed, composition, 15K, 5%, 1/2W	1067-1535	B, EB1535	1	1
R7	Resistor: fixed, carbon film, 775K, 1%, 1W	1082-0059	NN, type DC-1	1	1
R8	Resistor: fixed, carbon film, 200K, 1%, 1/2W	1076-0041	NN, type DC-1/2A	1	1
R9	Resistor: fixed, carbon film, 13.2K, 1%, 1/2W	1076-0087	NN, type DC-1/2	1	1
R10	Resistor: fixed, carbon film, 56K, 1%, 1W	1082-0058	NN, type DC-1	1	1
R11	Resistor: fixed, carbon film, 7.5M, 1%, 1W	1082-0044	NN, type DC-1	1	1
R12, 13	Resistor: fixed, carbon film, 87.5M, 1%, 2W	1085-0003	NN, type DC-2	2	1
R14	Resistor: fixed, carbon film, 3.3M, 1%, 1W (nominal value)	1082-0062	NN, type DC-1	1	1
R15	Resistor: fixed, carbon film, 49M, 1%, 2W	1085-0006	NN, type DC-2	1	1
R16	Resistor: fixed, carbon film, 1.39M, 1%, 1W (nominal value)	1082-0023	NN, type DC-1	1	1
R18	Resistor: fixed, carbon film, 144K, 1%, 1W (nominal value)	1082-0022	NN, type DC-1	1	1
R19	Resistor: fixed, carbon film, 3M, 1%, 1/2W	1076-0011	NN, type DC-1/2	1	1
R20	Resistor: fixed, carbon film, 49K, 1%, 1W (nominal value)	1082-0031	NN, type DC-1	1	1
R21	Resistor: fixed, carbon film, 820K, 1%, 1W (nominal value)	1082-0056	NN, type DC-1	1	1

* Manufacturers' code letters on last page. • Recommended 1-yr. isolated-use spares per MIL-E-17362A.

LIST OF CODE LETTERS USED IN TABLE OF REPLACEABLE PARTS TO DESIGNATE THE MANUFACTURERS

CODE LETTER	MANUFACTURER	ADDRESS
A	Aerovox Corp.	New Bedford, Mass.
B	Allen-Bradley Co.	Milwaukee 4, Wis.
C	Amperite Co.	New York, N. Y.
D	Arrow, Hart & Hegeman	Hartford, Conn.
E	Bussman Manufacturing Co.	St. Louis, Mo.
F	Carborundum Co.	Niagara Falls, N. Y.
G	Centralab	Milwaukee 1, Wis.
H	Cinch-Jones Mfg. Co.	Chicago 24, Ill.
HP	Hewlett-Packard Co.	Palo Alto, Calif.
I	Clarostat Mfg. Co.	Dover, N. H.
J	Cornell Dubilier Elec. Co.	South Plainfield, N. J.
K	Hi-Q Division of Aerovox	Olean, N. Y.
L	Erie Resistor Corp.	Erie 6, Pa.
M	Fed. Telephone & Radio Corp.	Clifton, N. J.
N	General Electric Co.	Schenectady 5, N. Y.
O	General Electric Supply Corp.	San Francisco, Calif.
P	Girard-Hopkins	Oakland, Calif.
Q	Industrial Products Co.	Danbury, Conn.
R	International Resistance Co.	Philadelphia 8, Pa.
S	Lectrohm Inc.	Chicago 20, Ill.
T	Littlefuse Inc.	Des Plaines, Ill.
U	Maguire Industries Inc.	Greenwich, Conn.
V	Micamold Radio Corp.	Brooklyn 37, N. Y.
W	Oak Manufacturing Co.	Chicago 10, Ill.
X	P. R. Mallory Co., Inc.	Indianapolis, Ind.
Y	Radio Corp. of America	Harrison, N. J.
Z	Sangamo Electric Co.	Marion, Ill.
AA	Sarkes Tarzian	Bloomington, Ind.
BB	Signal Indicator Co.	Brooklyn 37, N. Y.
CC	Sprague Electric Co.	North Adams, Mass.
DD	Stackpole Carbon Co.	St. Marys, Pa.
EE	Sylvania Electric Products Co.	Warren, Pa.
FF	Western Electric Co.	New York 5, N. Y.
GG	Wilkor Products, Inc.	Cleveland, Ohio
HH	Amphenol	Chicago 50, Ill.
II	Dial Light Co. of America	Brooklyn 37, N. Y.
JJ	Leecraft Manufacturing Co.	New York, N. Y.
KK	Switchcraft, Inc.	Chicago 22, Ill.
LL	Gremar Manufacturing Co.	Wakefield, Mass.
MM	Carad Corp.	Redwood City, Calif.
NN	Electra Manufacturing Co.	Kansas City, Mo.
OO	Acro Manufacturing Co.	Columbus 16, Ohio
PP	Alliance Manufacturing Co.	Alliance, Ohio
QQ	Arco Electronics, Inc.	New York 13, N. Y.
RR	Astron Corp.	East Newark, N. J.
SS	Axel Brothers Inc.	Long Island City, N. Y.
TT	Belden Manufacturing Co.	Chicago 44, Ill.
UU	Bird Electronics Corp.	Cleveland 14, Ohio
VV	Barber Colman Co.	Rockford, Ill.
WW	Bud Radio Inc.	Cleveland 3, Ohio
XX	Allen D. Cardwell Mfg. Co.	Plainville, Conn.
YY	Cinema Engineering Co.	Burbank, Calif.
ZZ	Any brand tube meeting RETMA standards.	
AB	Corning Glass Works	Corning, N. Y.
AC	Dale Products, Inc.	Columbus, Neb.
AD	The Drake Mfg. Co.	Chicago 22, Ill.
AE	Elco Corp.	Philadelphia 24, Pa.
AF	Hugh H. Eby Co.	Philadelphia 44, Pa.
AG	Thomas A. Edison, Inc.	West Orange, N. J.
AH	Fansteel Metallurgical Corp.	North Chicago, Ill.
AI	General Ceramics & Steatite Corp.	Keasbey, N. J.
AJ	The Gudeman Co.	Sunnyvale, Calif.
AK	Hammerlund Mfg. Co., Inc.	New York 1, N. Y.
AL	Industrial Condenser Corp.	Chicago 18, Ill.
AM	Insuline Corp. of America	Manchester, N. H.
AN	Jennings Radio Mfg. Corp.	San Jose, Calif.
AO	E. F. Johnson Co.	Waseca, Minn.
AP	Lenz Electric Mfg. Co.	Chicago 47, Ill.
AQ	Micro-Switch	Freeport, Ill.
AR	Mechanical Industries Prod. Co.	Akron 8, Ohio
AS	Model Eng. & Mfg., Inc.	Huntington, Ind.
AT	The Muter Co.	Chicago 5, Ill.
AU	Ohmite Mfg. Co.	Skokie, Ill.
AV	Resistance Products Co.	Harrisburg, Pa.
AW	Radio Condenser Co.	Camden 3, N. J.
AX	Shallcross Manufacturing Co.	Collingdale, Pa.
AY	Solar Manufacturing Co.	Los Angeles 58, Calif.
AZ	Sealectro Corp.	New Rochelle, N. Y.
BA	Spencer Thermostat	Attleboro, Mass.
BC	Stevens Manufacturing Co.	Mansfield, Ohio
BD	Torrington Manufacturing Co.	Van Nuys, Calif.
BE	Vector Electronic Co.	Los Angeles 65, Calif.
BF	Weston Electrical Inst. Corp.	Newark 5, N. J.
BG	Advance Electric & Relay Co.	Burbank, Calif.
BH	E. I. DuPont	San Francisco, Calif.
BI	Electronics Tube Corp.	Philadelphia 18, Pa.
BJ	Aircraft Radio Corp.	Boonton, N. J.
BK	Allied Control Co., Inc.	New York 21, N. Y.
BL	Augat Brothers, Inc.	Attleboro, Mass.
BM	Carter Radio Division	Chicago, Ill.
BN	CBS Hytron Radio & Electric	Danvers, Mass.
BO	Chicago Telephone Supply	Elkhart, Ind.
BP	Henry L. Crowley Co., Inc.	West Orange, N. J.
BQ	Curtiss-Wright Corp.	Carlstadt, N. J.
BR	Allen B. DuMont Labs	Clifton, N. J.
BS	Excel Transformer Co.	Oakland, Calif.
BT	General Radio Co.	Cambridge 39, Mass.
BU	Hughes Aircraft Co.	Culver City, Calif.
BV	International Rectifier Corp.	El Segundo, Calif.
BW	James Knights Co.	Sandwich, Ill.
BX	Mueller Electric Co.	Cleveland, Ohio
BY	Precision Thermometer & Inst. Co.	Philadelphia 30, Pa.
BZ	Radio Essentials Inc.	Mt. Vernon, N. Y.
CA	Raytheon Manufacturing Co.	Newton, Mass.
CB	Tung-Sol Lamp Works, Inc.	Newark 4, N. J.
CD	Varian Associates	Palo Alto, Calif.
CE	Victory Engineering Corp.	Union, N. J.
CF	Weckesser Co.	Chicago 30, Ill.
CG	Wilco Corporation	Indianapolis, Ind.
CH	Winchester Electronics, Inc.	Santa Monica, Calif.
CI	Malco Tool & Die	Los Angeles 42, Calif.
CJ	Oxford Electric Corp.	Chicago 15, Ill.
CK	Camloc-Fastener Corp.	Paramus, N. J.
CL	George K. Garrett	Philadelphia 34, Pa.
CM	Union Switch & Signal	Swissvale, Pa.
CN	Radio Receptor	New York 11, N. Y.
CO	Automatic & Precision Mfg. Co.	Yonkers, N. Y.
CP	Bassick Co.	Bridgeport 2, Conn.
CQ	Birnbach Radio Co.	New York 13, N. Y.
CR	Fischer Specialties	Cincinnati 6, Ohio
CS	Telefunken (c/o MVM, Inc.)	New York, N. Y.
CT	Potter-Brumfield Co.	Princeton, Ind.
CU	Cannon Electric Co.	Los Angeles, Calif.
CV	Dymec	Palo Alto, Calif.
CW	Good-All Electric Mfg. Co.	Ogallala, Nebr.

CLAIM FOR DAMAGE IN SHIPMENT

Unless otherwise specified with a purchase order, each Dymec instrument is purchased f. o. b. Palo Alto, California, subject to the terms in the purchase order acknowledgment. As soon as each instrument is received, inspect it for obvious and concealed damage, and test its operation. If the instrument is damaged, immediately file a claim with the carrier's agent; include a description of the instrument (model and serial numbers) and the extent of damage.

WARRANTY

Dymec warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Klystron tubes as well as other electron tubes, fuses and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken.

1. Notify us, giving full details of the difficulty, and include the model number and serial number. On receipt of this information, we will give you service data or shipping instructions.

2. On receipt of shipping instructions, forward the instrument prepaid, to the factory or to the authorized repair station indicated on the instructions. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the warranty.

SHIPPING

All shipments of Dymec instruments should be made via truck or Railway Express. The instruments should be packed in a strong exterior container and surrounded by two or three inches of excelsior or similar shock-absorbing material.

DO NOT HESITATE TO CALL ON US

DYMEC
A Division of Hewlett-Packard Co.
395 Page Mill Road
Palo Alto, California

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H	Cinch-Jones Mfg. Co.	Chicago 24, Ill.
HP	Hewlett-Packard Co.	Palo Alto, Calif.
I	Clarostat Mfg. Co.	Dover, N. H.
J	Cornell Dubilier Elec. Co.	South Plainfield, N. J.
K	Hi-Q Division of Aerovox	Olean, N. Y.
L	Erie Resistor Corp.	Erie 6, Pa.
M	Fed. Telephone & Radio Corp.	Clifton, N. J.
N	General Electric Co.	Schenectady 5, N. Y.
O	General Electric Supply Corp.	San Francisco, Calif.
P	Girard-Hopkins	Oakland, Calif.
Q	Industrial Products Co.	Danbury, Conn.
R	International Resistance Co.	Philadelphia 8, Pa.
S	Lectrohm Inc.	Chicago 20, Ill.
T	Littlefuse Inc.	Des Plaines, Ill.
U	Maguire Industries Inc.	Greenwich, Conn.
V	Micamold Radio Corp.	Brooklyn 37, N. Y.
W	Oak Manufacturing Co.	Chicago 10, Ill.
X	P. R. Mallory Co., Inc.	Indianapolis, Ind.
Y	Radio Corp. of America	Harrison, N. J.
Z	Sangamo Electric Co.	Marion, Ill.
AA	Sarkes Tarzian	Bloomington, Ind.
BB	Signal Indicator Co.	Brooklyn 37, N. Y.
CC	Sprague Electric Co.	North Adams, Mass.
DD	Stackpole Carbon Co.	St. Marys, Pa.
EE	Sylvania Electric Products Co.	Warren, Pa.
FF	Western Electric Co.	New York 5, N. Y.
GG	Wilkor Products, Inc.	Cleveland, Ohio
HH	Amphenol	Chicago 50, Ill.
II	Dial Light Co. of America	Brooklyn 37, N. Y.
JJ	Leecraft Manufacturing Co.	New York, N. Y.
KK	Switchcraft, Inc.	Chicago 22, Ill.
LL	Gremar Manufacturing Co.	Wakefield, Mass.
MM	Carad Corp.	Redwood City, Calif.
NN	Electra Manufacturing Co.	Kansas City, Mo.
OO	Acro Manufacturing Co.	Columbus 16, Ohio
PP	Alliance Manufacturing Co.	Alliance, Ohio
QQ	Arco Electronics, Inc.	New York 13, N. Y.
RR	Astron Corp.	East Newark, N. J.
SS	Axel Brothers Inc.	Long Island City, N. Y.
TT	Belden Manufacturing Co.	Chicago 44, Ill.
UU	Bird Electronics Corp.	Cleveland 14, Ohio
VV	Barber Colman Co.	Rockford, Ill.
WW	Bud Radio Inc.	Cleveland 3, Ohio
XX	Allen D. Cardwell Mfg. Co.	Plainville, Conn.
YY	Cinema Engineering Co.	Burbank, Calif.
ZZ	Any brand tube meeting RETMA standards.	
AB	Corning Glass Works	Corning, N. Y.
AC	Dale Products, Inc.	Columbus, Neb.
AD	The Drake Mfg. Co.	Chicago 22, Ill.
AE	Elco Corp.	Philadelphia 24, Pa.
AF	Hugh H. Eby Co.	Philadelphia 44, Pa.
AG	Thomas A. Edison, Inc.	West Orange, N. J.
AH	Fansteel Metallurgical Corp.	North Chicago, Ill.
AI	General Ceramics & Steatite Corp.	Keasbey, N. J.
AJ	The Gudeman Co.	Sunnyvale, Calif.
AK	Hammerlund Mfg. Co., Inc.	New York 1, N. Y.
AL	Industrial Condenser Corp.	Chicago 18, Ill.
AM	Insuline Corp. of America	Manchester, N. H.
AN	Jennings Radio Mfg. Corp.	San Jose, Calif.
AO	E. F. Johnson Co.	Waseca, Minn.
AP	Lenz Electric Mfg. Co.	Chicago 47, Ill.
AQ	Micro-Switch	Freeport, Ill.
AR	Mechanical Industries Prod. Co.	Akron 8, Ohio
AS	Model Eng. & Mfg., Inc.	Huntington, Ind.
AT	The Muter Co.	Chicago 5, Ill.
AU	Ohmite Mfg. Co.	Skokie, Ill.
AV	Resistance Products Co.	Harrisburg, Pa.
AW	Radio Condenser Co.	Camden 3, N. J.
AX	Shallcross Manufacturing Co.	Collingdale, Pa.
AY	Solar Manufacturing Co.	Los Angeles 58, Calif.
AZ	Sealectro Corp.	New Rochelle, N. Y.
BA	Spencer Thermostat	Attleboro, Mass.
BC	Stevens Manufacturing Co.	Mansfield, Ohio
BD	Torrington Manufacturing Co.	Van Nuys, Calif.
BE	Vector Electronic Co.	Los Angeles 65, Calif.
BF	Weston Electrical Inst. Corp.	Newark 5, N. J.
BG	Advance Electric & Relay Co.	Burbank, Calif.
BH	E. I. DuPont	San Francisco, Calif.
BI	Electronics Tube Corp.	Philadelphia 18, Pa.
BJ	Aircraft Radio Corp.	Boonton, N. J.
BK	Allied Control Co., Inc.	New York 21, N. Y.
BL	Augat Brothers, Inc.	Attleboro, Mass.
BM	Carter Radio Division	Chicago, Ill.
BN	CBS Hytron Radio & Electric	Danvers, Mass.
BO	Chicago Telephone Supply	Elkhart, Ind.
BP	Henry L. Crowley Co., Inc.	West Orange, N. J.
BQ	Curtiss-Wright Corp.	Carlstadt, N. J.
BR	Allen B. DuMont Labs	Clifton, N. J.
BS	Excel Transformer Co.	Oakland, Calif.
BT	General Radio Co.	Cambridge 39, Mass.
BU	Hughes Aircraft Co.	Culver City, Calif.
BV	International Rectifier Corp.	El Segundo, Calif.
BW	James Knights Co.	Sandwich, Ill.
BX	Mueller Electric Co.	Cleveland, Ohio
BY	Precision Thermometer & Inst. Co.	Philadelphia 30, Pa.
BZ	Radio Essentials Inc.	Mt. Vernon, N. Y.
CA	Raytheon Manufacturing Co.	Newton, Mass.
CB	Tung-Sol Lamp Works, Inc.	Newark 4, N. J.
CD	Varian Associates	Palo Alto, Calif.
CE	Victory Engineering Corp.	Union, N. J.
CF	Weckesser Co.	Chicago 30, Ill.
CG	Wilco Corporation	Indianapolis, Ind.
CH	Winchester Electronics, Inc.	Santa Monica, Calif.
CI	Malco Tool & Die	Los Angeles 42, Calif.
CJ	Oxford Electric Corp.	Chicago 15, Ill.
CK	Camloc-Fastener Corp.	Paramus, N. J.
CL	George K. Garrett	Philadelphia 34, Pa.
CM	Union Switch & Signal	Swissvale, Pa.
CN	Radio Receptor	New York 11, N. Y.
CO	Automatic & Precision Mfg. Co.	Yonkers, N. Y.
CP	Bassick Co.	Bridgeport 2, Conn.
CQ	Birnbach Radio Co.	New York 13, N. Y.
CR	Fischer Specialties	Cincinnati 6, Ohio
CS	Telefunken (c/o MVM, Inc.)	New York, N. Y.
CT	Potter-Brumfield Co.	Princeton, Ind.
CU	Cannon Electric Co.	Los Angeles, Calif.
CV	Dymec	Palo Alto, Calif.
CW	Good-All Electric Mfg. Co.	Ogallala, Nebr.

CLAIM FOR DAMAGE IN SHIPMENT

Unless otherwise specified with a purchase order, each Dymec instrument is purchased f. o. b. Palo Alto, California, subject to the terms in the purchase order acknowledgment. As soon as each instrument is received, inspect it for obvious and concealed damage, and test its operation. If the instrument is damaged, immediately file a claim with the carrier's agent; include a description of the instrument (model and serial numbers) and the extent of damage.

WARRANTY

Dymec warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Klystron tubes as well as other electron tubes, fuses and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken.

1. Notify us, giving full details of the difficulty, and include the model number and serial number. On receipt of this information, we will give you service data or shipping instructions.

2. On receipt of shipping instructions, forward the instrument prepaid, to the factory or to the authorized repair station indicated on the instructions. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the warranty.

SHIPPING

All shipments of Dymec instruments should be made via truck or Railway Express. The instruments should be packed in a strong exterior container and surrounded by two or three inches of excelsior or similar shock-absorbing material.

DO NOT HESITATE TO CALL ON US

DYMEC
A Division of Hewlett-Packard Co.
395 Page Mill Road
Palo Alto, California

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